DOCUMENT RESUME

ED 279 800 CE 046 459

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TITLE Machine Shop Grinding Machines.
INSTITUTION Oklahoma State Board of Vocational and Technical Education, Stillwater. Curriculum and Instructional Materials Center.
PUB DATE 83
NOTE 310p.; For related learning activity packets, see CE 046 460-462.
AVAILABLE FROM Curriculum and Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, OK 74074 (Order No. TI 3104: $4.00 in state, $20.00 out of state).
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Adult Education; Behavioral Objectives; Job Skills; Learning Activities; *Machine Tool Operators; *Machine Tools; Postsecondary Education; Secondary Education; State Curriculum Guides; *Trade and Industrial Education; Transparencies
IDENTIFIERS Oklahoma

ABSTRACT

This curriculum manual is one in a series of machine shop curriculum manuals intended for use in full-time secondary and postsecondary classes, as well as part-time adult classes. The curriculum can also be adapted to open-entry, open-exit programs. Its purpose is to equip students with basic knowledge and skills that will enable them to enter the machine trade at the machine operator level. The curriculum guide includes three instructional units: introduction to grinding machines, surface grinding, and cylindrical grinding. Each unit consists of eight basic components: performance objectives (both unit and specific objectives), suggested activities for the teacher, information sheets (content essential for meeting the cognitive objectives, written in topical outline form and keyed to specific objectives), assignment sheets, job sheets (a list of equipment, tools, and materials needed to complete a manipulative or psychomotor skill), transparency masters, tests, and answers to tests and assignment sheets. (YLB)

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Machine Shop

Grinding Machines

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CE 046459

84-002128

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State Department of Vocational and Technical Education
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MACHINE SHOP

GRINDING MACHINES

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FOREWORD

In Oklahoma, vocational educators have a basic belief that quality vocational programs require the use of sound instructional materials. It is this belief that prompted the Oklahoma State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center to develop a curriculum tailored to provide high-quality and uniform training materials for the machinist trade. *Machine Shop: Grinding Machines* is part of a series of machine shop curriculum manuals published by the CIMC. The first manual, *Machine Shop I,* provides information basic to the machinist trade. Other volumes deal with lathes, shapers, and milling machines.

Industry representatives, classroom teachers, and technical specialists collaborated closely to produce materials that will provide each student with information and practical learning experiences directly applicable to the machinist trade. Whether the students are beginners in the trade, seasoned machinists upgrading skills, or skilled machinists reviewing procedures and using these materials as reference, they can appreciate the expertise of all those who created *Machine Shop: Grinding Machines.*

The information in *Machine Shop: Grinding Machines* should be adapted, personalized, and localized so that this publication will become a vital part of the teaching/learning process. It is my sincere hope that *Machine Shop: Grinding Machines* and the other manuals in this series will contribute to the development of a competent, safety-conscious workforce in the machine shop trade.

Francis Tuttle, Director
Oklahoma State Department of
Vocational and Technical Education

Ivan Armstrong, State Supervisor
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Oklahoma State Department of
Vocational and Technical Education

PREFACE

The purpose of *Machine Shop: Grinding Machines* is to equip students with basic knowledge and skills that will enable them to enter the machine trade at the machine operator level.

This curriculum has been designed so that it may be used in full-time secondary and post-secondary classes, as well as part-time adult classes. It can also be adapted to open-entry, open-exit programs so that each student may progress at his or her own pace.

The assignment sheets and job sheets are the chief strengths of this volume. They are directly related to the lesson and provide for appropriate practice with pencil and paper and actual hands-on jobs using the machinery of the trade. The material is competency based in that the objectives of each unit are measurable to a minimum standard of acceptance.

Machine Shop: Grinding Machines supplements *Machine Shop I*, but the subject material in the manual is not necessarily arranged in the order of instruction. It is recommended that the instructor arrange the units in this volume to meet individual teaching needs. All or part of a unit may be taught at a given time.

A skilled instructor who can supplement, personalize, and localize this material will go a long way toward helping the learner advance in the machine trade, which is changing at a fantastic rate. These changes have created a great demand for workers with job-ready skills. I hope that the manuals in this series aid instructors in training the workers needed by the trade.

James Dunn, Trade and Industrial
Curriculum Specialist

ACKNOWLEDGEMENTS

I am indeed grateful for the generous contribution of time, expertise, and cooperation given by committee members and the schools or industries they represent.

Special thanks to Mercury Marine and Halliburton Services for releasing employees to serve on the committee. *Machine Shop: Grinding Machines* would not have become a reality without the combined efforts of the following people:

Tom Fite — Mercury Marine, Stillwater, Oklahoma
Bill Hill — State Department of Vocational and Technical Education, Stillwater, Oklahoma
Ken Hulsizer — State Department of Vocational and Technical Education, Stillwater, Oklahoma
Cylde Knight — Oklahoma State University, Stillwater, Oklahoma
Ralph Moore — Tulsa AVTS at Peoria, Tulsa, Oklahoma
Kenneth Morgan — Halliburton Services, Duncan, Oklahoma
Ken Robb — Tulsa AVTS at Memorial, Tulsa, Oklahoma
Mitchell Slemp — Mid-America AVTS, Wayne, Oklahoma
James Sharpton — State Department of Vocational and Technical Education, Stillwater, Oklahoma
Wesley Taylor — Caddo-Kiowa AVTS, Fort Cobb, Oklahoma

I would also like to express my appreciation to the following companies for granting permissions for many of the illustrations used in this manual.

Brown and Sharpe Manufacturing Company,
North Kingston, Rhode Island
The Norton Company, Worcester, Massachusetts
Covel Manufacturing Company, Division of Clausing Corporation, Kalamazoo, Michigan

Deep appreciation is expressed to my co-workers Joyce Sawatzky and Robert Hilley for assisting me with the development of this curriculum. Sincere appreciation is extended to Bob Patton for giving me the opportunity to write this curriculum and for providing superior leadership during the development and publication of this manual. A great deal of the credit for the readability and clarity of this materials goes to the CIMC editing staff under Terra McCluskey. Their help and guidance, their attention to detail, and their concern for a quality product were invaluable in completing this project. My gratitude goes to Terri Barnes, Susan Walker, Jerry Weir, Sue Buck, Barbara Harrison, and Sue Feasley.

Special recognition goes to staff members from the Curriculum and Instructional Materials Center and the Graphics Division of the State Department of Vocational and Technical Education for their services offered during the development and publication of this manual. Most notably, recognition goes to Dana Welborne and Nancy Hilley, who provided many of the excellent illustrations used to supplement the instructional materials, and to the members of the Communications Center, who, under the supervision of Jenny Fowler, typed and typeset the many drafts and revisions required during development. Those most involved in the typing for this volume include Dona Landreth, Gari Sha Robinson, Lori White, Rose Primeaux, and Allison McLaughlin. Finally, the services of the Print Shop, under Noel Wilcoxson, produced the quality appearance of this material.

Instructional Units

Machine Shop: Grinding Machines includes three instructional units. A standard format was established in 1970 for the development of instructional materials for all Oklahoma vocational teachers. This format includes eight basic components that form a unit of instruction: performance objectives, suggested activities for the teacher, information sheets, assignment sheets, job sheets, transparency masters, tests, and answers to tests and assignment sheets. Depending on the specific objectives, transparency masters, assignment sheets, and job sheets may or may not be included in the unit of instruction.

All of the unit components "zero in" on measurable and observable learning outcomes. Teachers are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the teacher will help him or her determine the following

A. Amount of material that can be covered in each class period
B. Skills that must be demonstrated
    1. Supplies and equipment needed
    2. Amount of practice needed
    3. Amount of class time needed for demonstrations
C. Supplementary materials, such as pamphlets and filmstrips, that must be ordered
D. Resource people who must be contacted

Performance Objectives (white pages)

Each unit of instruction is based on the performance needed for successful employment in an occupational area. Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction, and specific objectives, stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching/learning process, it is important that teachers and students have a common understanding of the intent of the objectives. Following is a list of performance terms, their meanings, and behavioral synonyms that may have been used in this material.

A. Name — The individual supplies a name for objects, events, or people

    Behavioral synonyms: Label, list, letter, record, reiterate, repeat, write

B. Identify — The individual selects a named, described, or pictured object by pointing to it, touching it, picking it up, or selecting it

    Behavioral synonyms: Select, mark, match, choose, judge

C. State a rule — The individual communicates a relationship or principle that could be used to solve problems or perform a task

D. Apply a rule — The individual supplies an answer to a problem by using a stated relationship or principle

Behavioral synonyms: Solve, calculate

E. Describe — The individual relates sufficient characteristics or properties of an object or event so that a second individual will be able to state what is being discussed

Behavioral synonyms: Define, discuss, interpret, recite, tell how, tell what happens when

F. Distinguish — The individual selects an object or event from two or more that are easily confused

Behavioral synonyms: Discriminate, differentiate

G. Order — The individual arranges three or more objects or events in a sequence based on a stated property

Behavioral synonyms: Arrange, sequence, list in order, classify, divide, isolate, sort

H. Construct — The individual makes a physical object, a verbal statement, or a drawing

(NOTE: *Construct* is used when the finished product or result is important.)

Behavioral synonyms: Draw, make, build, design, formulate, reproduce, transcribe, convert, put together, compile

I. Demonstrate — The individual performs several operations necessary to carry out a specified process

(NOTE: *Demonstrate* is used when it is desirable to watch the student perform a task, one of the highest levels of student performance.)

Behavioral synonyms: Show your work, show procedure, perform an experiment, perform the steps, operate, remove, replace, turn off/on, (dis)assemble, (dis)connect

The objectives should be provided for students and stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Prepare for each unit by deciding how each objective can best be taught.

The objective sheet may also be used as a quick pretest to determine prior knowledge of students and to determine whether further study or activities are necessary. Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When changes in objectives are made, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

Suggested Activities (pink pages)

This component is included only in teacher material. The suggested activities page assists teachers during the preparation stage of the teaching/learning process by providing suggestions for delivery and/or presentation during the instructional process. Read the suggested activities before teaching the units so that supplemental materials can be obtained, audio-visual materials prepared, and outside resources contacted. Duties of the teacher will vary according to the particular unit.

The references that are listed are ones used in the development of each unit. They should be used by the teacher to supplement knowledge of the subject area or to help students with particular interests or occupational objectives in the area covered.

Information Sheet (green pages)

The information sheet provides "must know" content essential for meeting the cognitive (knowledge level) objectives of the unit. The information is written in a topical outline form and is keyed to the specific objectives.

Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. The information sheet may also be used for coordination activities and advisory committees.

Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and teachers to add notes that supplement, localize, personalize, or provide motivation for each unit.

Transparency Masters (white pages in teacher material and green in student material)

Transparency masters provide information in a special way. Transparencies direct the class' attention to the topic of discussion. Transparencies may present new information, or they may reinforce information presented in the information sheet. They are particularly effective when identification is necessary. Transparencies should be made and placed in the notebook where they will be immediately available for use.

Assignment Sheets (brown pages)

Assignment sheets give students a chance at problem solving, self-assessment, and/or practical experience with the information. They assist students in the application of knowledges that are necessary prerequisites to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided when appropriate and can be used by the student and/or teacher for checking student progress.

Job Sheets (blue pages)

Job sheets are another important segment of a unit of instruction. The job sheets provide a list of equipment, tools, and materials needed to complete a manipulative or psychomoter skill. They describe a step-by-step procedure needed to complete each task or job. Diagrams, photographs, and illustrations are provided to assist students in achieving the skill.

A teacher should demonstrate to students the procedures outlined in each job sheet. Furthermore, the teacher needs to localize the job sheet according to the equipment and supplies available in the local lab or shop situation. Job sheets also furnish potential employers with a picture of the skills being taught and the performances they might reasonably expect from a person who has had this vocational instruction.

Tests (yellow pages)

This component provides criterion-referenced evaluation of every objective listed in the unit of instruction. It is crucial to note that both paper/pencil and performance objectives must be evaluated.

The tests may be written or oral. It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of questions from the units covered may be used for final tests at the end of each term if desired. If objectives have been added, deleted, or modified, be sure to make the changes on the test.

The acceptable response on a unit test — 85 percent in most units — may be raised or lowered to fit the topic or students' ability levels. The percentage applies to the overall score, not to each question. The final unit grade should be obtained by using the paper/pencil score along with teacher evaluations of student demonstrations of the desired skills.

Answers to Test and Assignment Sheets (pink pages)

These components are designed to assist the teacher in evaluation of student performances.

Page Numbering

Each unit from the Curriculum and Instructional Materials Center is assigned a specific abbreviation. For example, *Machine Shop: Grinding Machines* has been abbreviated GM. The units are then numbered consecutively. An example of a page number is GM-1. Since CIMC publications are loose leaf, this system of page numbering was adopted so that pages from different manuals would not get mixed up.

Methods of Disseminating Material

Material may be given out a unit or page at a time to keep the material before the student always new. Upon its completion, each unit is then placed in a large binder. The large binders may be purchased at cost from the CIMC. Some teachers have stored the materials by units in filing cabinets or boxes until needed. All the units may be given out at once if desired.

For best results, provide student materials for each student. Student materials contain everything but the test answers, answers to assignment sheets, and suggested activities. All tests are collated at the back of student material and should be removed and stored until needed. Students should be allowed to take their materials home.

Teaching Methods

It is a challenge to keep students motivated. Supplement the objectives by providing the "why," personal experiences, and current information. Prepare for each unit by deciding how each objective can best be taught. Allow students to become involved in preparing and planning.

GRINDING MACHINES
UNIT I

UNIT OBJECTIVE

After completing this unit, the student should be able to identify types of grinding machines and name the basic parts of the surface and cylindrical grinder. The student should also be able to state the safety rules for operating grinding machines. The student will show this knowledge by completing assignment sheets, job sheets, and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with grinding machines to their correct definitions.
2. Match grinding machine operations to their correct descriptions.
3. Label the parts of a grinding wheel.
4. Match grinding wheel types to their common applications.
5. Match grinding wheel compositions to their correct descriptions.
6. Name reasons for truing and balancing grinding wheels.
7. Identify types of abrasive cutting machines.
8. Identify the parts of a surface grinder.
9. Match parts of a surface grinder to their correct functions.
10. Identify major parts of a cylindrical grinder.
11. Match major parts of a cylindrical grinder to their correct functions.
12. Identify selected controls and components of a cylindrical grinder.
13. Name the methods of applying coolant.
14. Match grinding operation problems to their correct descriptions.
15. Select from a list possible causes of grinding operation problems.
16. State rules for grinding machine safety.
17. Interpret grinding wheel markings.

OBJECTIVE SHEET

18. Demonstrate the ability to

    a. Operate surface grinder controls properly.

    b. Operate cylindrical grinder controls properly for manual feeds.

    c. Operate cylindrical grinder controls properly for power feeds.

    d. Balance a grinding wheel.

    e. Mount a chuck to headstock.

GRINDING MACHINES
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities

A. Make transparencies.

B. Provide students with objective sheet.

C. Discuss unit and specific objectives.

D. Provide students with information, assignment, and job sheets.

E. Discuss information and assignment sheets.

F. Discuss reasons for grinder safety and demonstrate safe grinding practices.

G. Take field trip to plant with grinding as main type of operation.

H. Demonstrate and discuss procedures outlined in job sheets.

(NOTE: Job sheets may need to be modified for the types of grinders used.)

I. Give test.

J. Reteach and retest if necessary.

II. Instructional materials

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency masters

1. TM #1 — Parts of a Surface Grinder
2. TM #2 — Major Parts of a Cylindrical (Universal) Grinder
3. TM #3 — Parts of the Headstock of a Cylindrical (Universal) Grinder
4. TM #4 — Parts of the Upright of a Cylindrical (Universal) Grinder
5. TM #5 — Cylindrical (Universal) Grinder Controls on Left Front of Machine
6. TM #6 — Cylindrical (Universal) Grinder Controls on Right Front of Machine
7. TM #7 — Cylindrical (Universal) Grinder Controls on Center Front of Machine
8. TM #8 — Parts of the Footstock of a Cylindrical (Universal) Grinder

9. TM #9 — Parts of the Swivel Table Adjustment

E. Assignment sheets

1. Assignment Sheet #1 — Identify Causes of Grinding Problems
2. Assignment Sheet #2 — State Rules for Safe Use of Grinding Machines
3. Assignment Sheet #3 — Interpret Grinding Wheel Markings

F. Answers to assignment sheets

G. Job sheets

1. Job Sheet #1 — Operate Surface Grinder Controls Properly
2. Job Sheet #2 — Operate Cylindrical Grinder Controls Properly for Manual Feeds
3. Job Sheet #3 — Operate Cylindrical Grinder Controls Properly for Power Feeds
4. Job Sheet #4 — Balance a Grinding Wheel
5. Job Sheet #5 — Mount a Chuck to Headstock

H. Test

I. Answers to test

III. Unit references

A. Burghardt, Henry D., Aaron Axelrod, and James Anderson. *Machine Tool Operations,* Part II. New York: McGraw-Hill, 1960.

B. Krar, S.F., and J.W. Oswald. *Grinding Technology.* Albany, New York: Litton Educational Publishers, Inc., 1974.

C. *Operator's Manual #21-9990-5: Operation and Maintenance of the No. 1 Universal Grinding Machine.* North Kingstown, Rhode Island: Brown and Sharpe Co., n.d.

D. *Operator's Manual #23-99990-11: Operation and Maintenance of 618 Micrometer Surface Grinding Machine.* North Kingstown, Rhode Island: Brown and Sharpe Co., n.d.

E. White, Warren T., et al. *Machine Tools and Machining Practices,* Volume II. New York: John Wiley and Sons, 1977.

GRINDING MACHINES
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Balancing — Adding, subtracting, or positioning weights on grinding wheel hub so that wheel weight will be evenly distributed

B. Burr — Turned-over edge of metal caused by grinding operation

C. Cutter — Part of grinding wheel dresser that comes into contact with wheel and does the dressing or shaping

D. Dressing — Process to improve or alter cutting action of grinding wheel

E. Generated heat — Increased temperature of workpiece and wheel caused by friction of grinding

F. Glazing — Dulling of cutting particles of grinding wheel; results in decreased cutting efficiency

G. Honing — Operation using bonded abrasive stick in special holder to remove stock and produce a desired surface accuracy

H. Loaded — Condition of grinding wheel in which the pores are filled with material being ground; results in poor finish on workpiece and reduced cutting action of wheel

I. Operating or wheel speed — Speed of revolving grinding wheel expressed in revolutions per minute (rpm) or surface feet per minute (sfm)

J. Profilometer — Instrument for measuring the degree of surface roughness in microinches (0.000001 inch)

K. Scale — Black layer on surface of steel that has been heat-treated or formed hot; must be removed before grinding

L. Wheel traverse speed — Rate of movement of grinding wheel across workpiece

M. Work speed — Rate at which workpiece or table traverse is moving; measured in feet per minute

N. Medium — Solution used to carry or suspend abrasive particles during lapping operations; plural, *media*

II. Grinding machine operations

A. Rough grinding — First grinding operation to reduce stock rapidly without particular regard to finish produced

B. Finish grinding — Final grinding operation to improve dimensional accuracy and obtain desired or near desired finish

INFORMATION SHEET

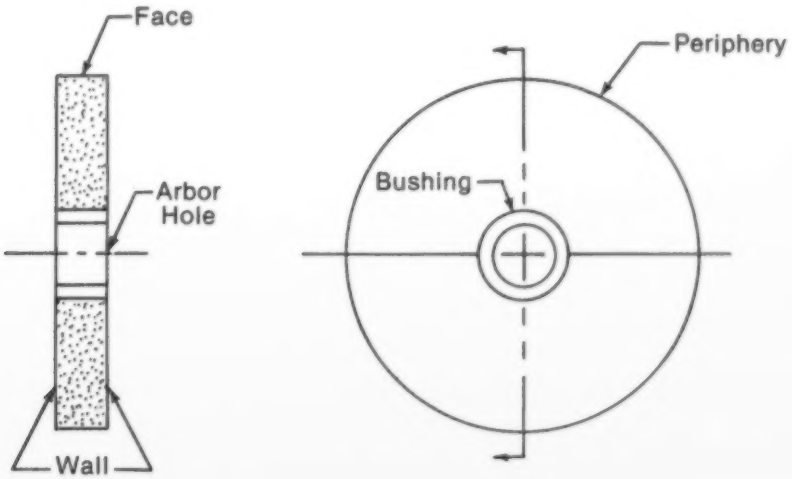
C. Lapping — Finishing process that uses loose abrasive grains carried by a medium to produce a desired surface finish

D. Snagging — Process of grinding the gates, fins, and spurs from castings

III. Parts of a grinding wheel (Figure 1)

(NOTE: The bushing is generally lead, aluminum, or babbitt alloy.)

FIGURE 1

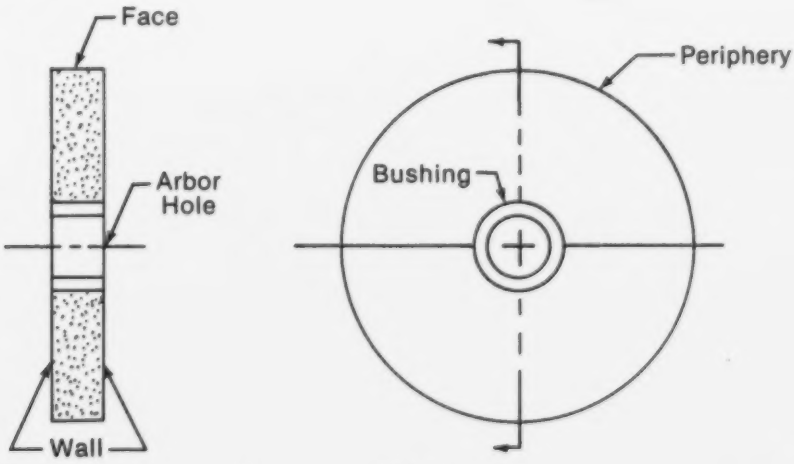


IV. Grinding wheel types and applications (Figures 2-7)

A. Type #1 — Straight wheel used for surface, internal, cylindrical, and off-hand grinding machine operations

EXAMPLE:

FIGURE 2

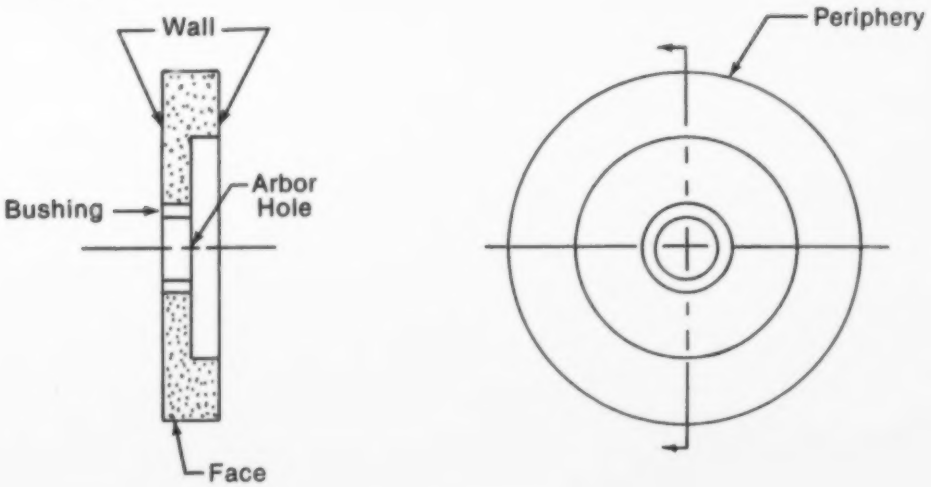


INFORMATION SHEET

B. Type #5 — Straight grinding wheel recessed on one side so that greater wheel thickness can be used; used primarily for surface, cylindrical, and off-hand grinding machine operations

EXAMPLE:

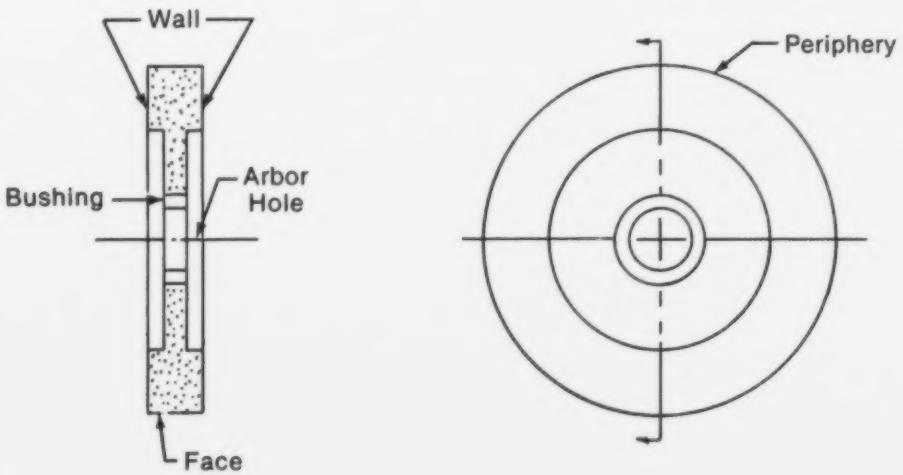
FIGURE 3



C. Type #7 — Straight wheel recessed on both sides; used primarily for surface and cylindrical grinding machine operations

EXAMPLE:

FIGURE 4

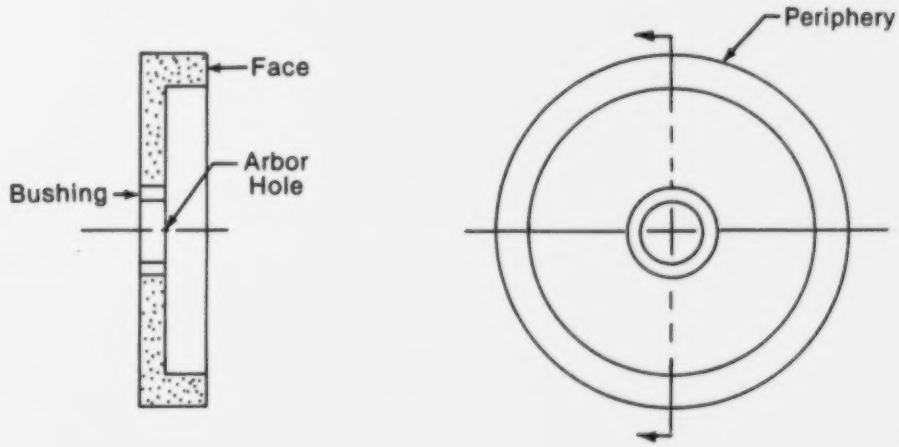


INFORMATION SHEET

D. Type #6 — Straight-cup wheel designed for side grinding and used primarily for cutter grinding; large sizes of this type are used on vertical spindle grinders

EXAMPLE:

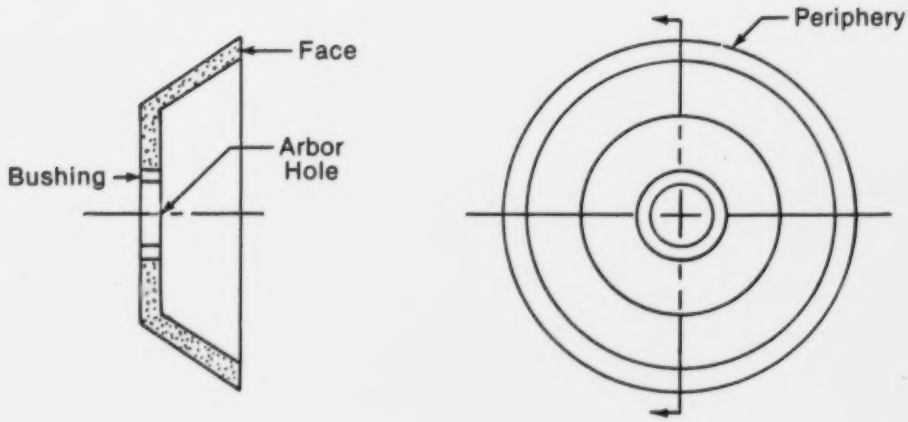
FIGURE 5



E. Type # 11 — Flaring-cup wheel designed for side grinding and used primarily for tool and cutter grinding

EXAMPLE:

FIGURE 6

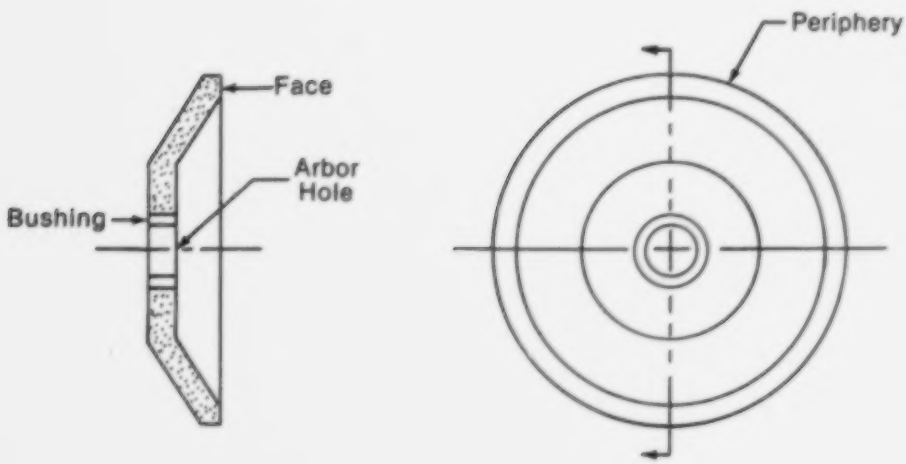


INFORMATION SHEET

F. Type #12 — Dish wheel designed for side grinding with periphery grinding possible; used primarily for toolroom grinding because its thinness permits grinding in narrow places

EXAMPLE:

FIGURE 7



V. Composition of grinding wheels (Assignment Sheet #3)

(NOTE: Different manufacturers use different numbering systems to designate the composition of their grinding wheels.)

A. Abrasive — Material in the grinding wheel that acts as the cutting agent; designated with numbers and letters, with the letters identifying the main base

EXAMPLES: A = aluminum oxide or Alundum, C = silicon carbide or Crystolon, D = diamond, 32A = aluminum oxide

B. Grain or grit — Size of abrasive expressed as a number from 10 (coarse) to 600 (very fine)

EXAMPLES:	32A16	32A36	32A80	32A400
	coarse	medium	fine	very fine

C. Grade — Strength of the bond that holds wheel abrasives together; determines rate at which wheel will break down; designated by letters from A (soft) to Z (hard)

EXAMPLES: 32A 36-**D** soft 32A 36-**J** medium 32A 36-**R** hard

D. Structure — Grain spacing designated by a number from 1 to 12; the higher the number, the more "open" the structure (Figures 8 and 9)

EXAMPLES:

FIGURE 8

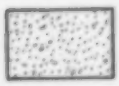
32A36-H6  abrasives are close to each other

FIGURE 9

32A36-H10 abrasives are farther apart

E. Bond — Material that holds abrasive together; designated by a letter or letters and/or numbers

(NOTE: The letter designating the bond will be **V** [vitrified], **B** [resinoid], **R** [rubber], or **E** [shellac]. This letter may be followed by other letters or numbers that represent a modification or variation in the bond or some other characteristic of the wheel.)

EXAMPLE: 32A46 — H8**V** vitrified bond

VI. Reasons for truing and balancing grinding wheels

A. To make the wheel concentric with spindle of grinding machine

B. To eliminate chatter marks

C. To eliminate vibration

D. To prevent wheel breakage

E. To prevent excessive bearing failure and damage to spindle

INFORMATION SHEET

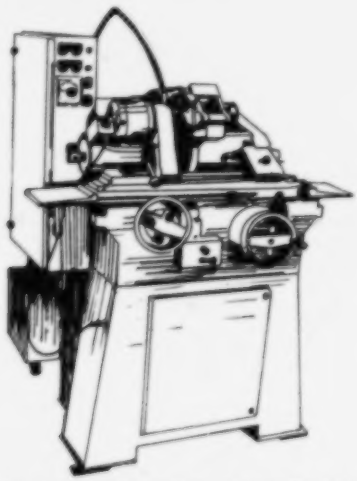
VII. Types of abrasive cutting machines (Figures 10-13)

(NOTE: Special application grinders include angular wheel slide machine, centerless grinder, roll grinder, jig grinder, vibrating finisher, honing machine, and lapping machine.)

A. Internal/external grinder

(NOTE: Some grinding machines will do both internal and external grinding, others are designed for internal or external grinding only.)

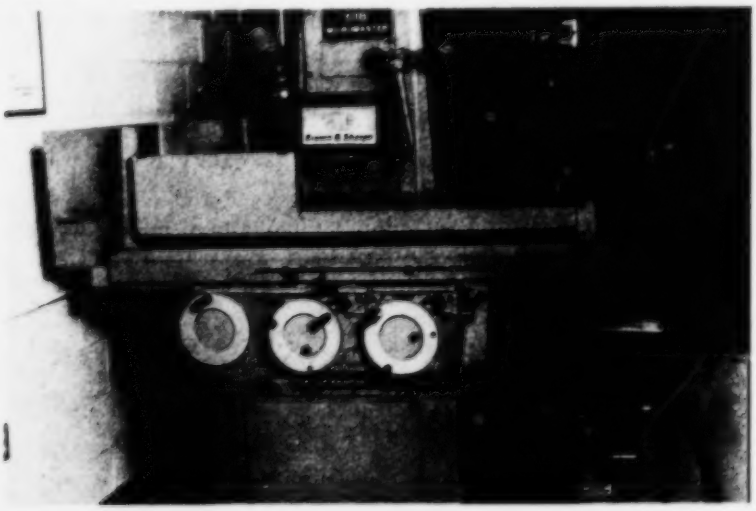
FIGURE 10



Used with permission of Covel Manufacturing Company Division of Clausing Corporation, Kalamazoo, Michigan.

B. Surface grinder

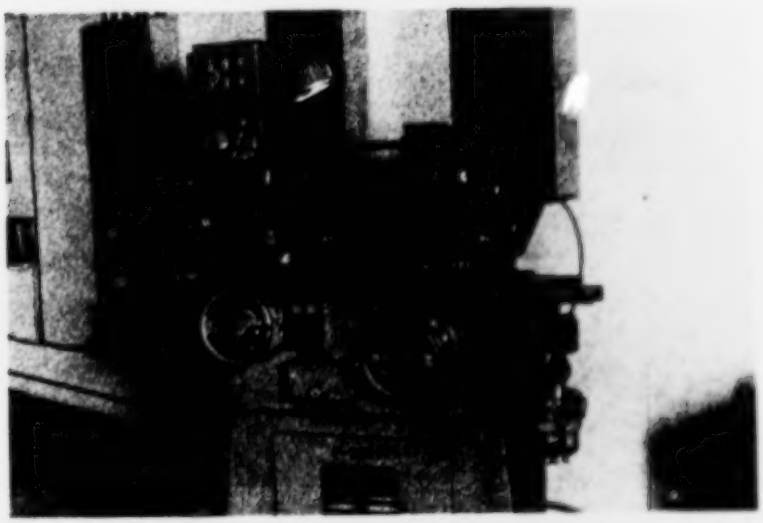
FIGURE 11



INFORMATION SHEET

C. Universal grinder

FIGURE 12



D. Universal and tool grinder

FIGURE 13

INFORMATION SHEET

VIII. Parts of a surface grinder (Transparency #1)

A. Spindle

B. Upright

C. Table

D. Table dogs

E. Fine-feed adjustment knob

F. Elevating handwheel

G. Fine-feed locknut

H. Cross-feed directional lever

I. Cross-feed regulating screw

J. Wheel truing and rapid positioning lever

K. Oil level sight glass

L. Cross-feed handwheel

M. Dial locknut

N. Table handwheel

O. Dust deflector

P. Table-reversing lever

Q. Wheel guard

IX. Functions of the parts of a surface grinder

A. Spindle — Aligns grinding wheel mounting hub and secures hub so that it will run true

B. Upright — Houses motor, spindle, and elevating mechanism; moves in and out on ways by means of cross-feed regulating screw

C. Table — Provides a flat surface to which workpiece or work-holding devices are mounted

D. Table dogs — Regulate length of table travel by tripping table-reversing lever

E. Fine-feed adjustment knob — Raises and lowers elevating mechanism of spindle; each graduation is 0.0002 inch

F. Elevating handwheel — Provides rapid movement of spindle up and down

G. Fine-feed locknut — When tightened, engages fine-feed adjustment knob; when loose, allows rapid movement by handwheels

H. Cross-feed directional lever — Engages power-feed mechanism and allows upright to move in or out by power

I. Cross-feed regulating screw — Regulates amount of step-over for each cut the wheel makes

J. Wheel truing and rapid positioning lever — Moves upright in and out, overrides the feed setting, and moves at a set rapid rate

K. Oil level sight glass — Allows visual inspection of oil level

L. Cross-feed handwheel — Moves upright toward and away from table

M. Dial locknut — Allows outer graduated ring of cross-feed or elevating wheel to be moved or set without moving feed mechanism

N. Table handwheel — Moves table right or left

O. Dust deflector — Shields user from dust and chipped particles from wheel or workpiece

P. Table-reversing lever — Changes direction of table when moving right or left by power feed

Q. Wheel guard — Helps control grinding dust and serves as protective guard in the event that grinding wheel explodes

X. Major parts of a cylindrical grinder (Transparency #2)

A. Headstock

B. External spindle

C. Internal spindle

D. Footstock

E. Electrical control compartment

F. Machine start/stop push buttons

INFORMATION SHEET

G. Cross-feed handwheel

H. Table-reversing lever

I. Table handwheel

J. Table dogs

K. Sliding table

L. Swivel table

XI. Functions of major parts of a cylindrical grinder

A. Headstock — Supports workpiece and revolves workpiece at set surface feet per minute rate

(NOTE: Center can be live or dead.)

B. External spindle — Holds wheel and wheel hub for external grinding

C. Internal spindle — Holds internal quill and wheels for grinding

D. Footstock — Holds workpiece when set up between centers

E. Electrical control compartment — Houses main power controls for all electrical components

F. Machine start/stop push buttons — Start external spindle and provide power to other controls

G. Cross-feed handwheel — Moves upright in (toward table) or out (away from table) by manual feed

H. Table-reversing lever — Reverses direction of sliding table when table is under power feed

I. Table handwheel — Moves sliding table right and left by manual feed

J. Table dogs — Regulate direction of table movement by striking table-reversing lever as table moves by power feed

K. Sliding table — Main part of table; moves right and left by power or manual feed; carries swivel table

L. Swivel table — Top part of sliding table; has T-slot for mounting work-holding devices or wheel dresser; adjustable to allow grinding of tapers

INFORMATION SHEET

XII. Selected controls and components of a cylindrical grinder (Transparencies #3-#9)

A. Headstock (Transparency #3)

1. Headstock motor
2. Spindle-locking plunger
3. Center
4. Work-driving arm
5. Work-driving plate
6. Index finger
7. Headstock base clamp bolts
8. Swivel clamp bolt

B. Upright (Transparency #4)

1. Internal grinding spindle motor
2. Motor pulley
3. External grinding spindle motor
4. Motor sheave
5. Wheel sleeve, right
6. External grinding spindle
7. Wheel slide
8. Turret locking-pin knob
9. Wheel slide base
10. Wheel slide water guard
11. Wheel spindle head
12. Universal turret
13. Wheel guard, left

INFORMATION SHEET

14. Internal spindle bracket
15. Internal grinding spindle unit
16. Locking-screw knob

C. Controls on left front of machine (Transparency #5)

1. Headstock and table control lever
2. Table-reversing lever
3. Headstock jog button
4. Handwheel shaft-locking plunger knob
5. Table dwell switches
6. Feed, right on/off
7. Amount of cross-feed knob
8. Feed, left on/off
9. Table speed selector knob
10. Table handwheel

D. Controls on right front of machine (Transparency #6)

1. Switch operating slide throw-out lever
2. Cross-feed gear-shifting knob
3. Headstock speed control knob
4. Internal/external grinding selector knob
5. Machine start/stop push buttons
6. Lever/handwheel selector switch
7. Cross-feed handwheel
8. Disengagement knob
9. Index plunger
10. Cross-feed control lever

INFORMATION SHEET

E. Controls on center front of machine (Transparency #7)

1. Adjusting screw knob, left
2. Table dog pawl lever, right
3. Table dog, left
4. Table dog clamp bolt
5. Table dog pawl lever, left
6. Check nut
7. Adjusting screw knob, right
8. Table dog, right
9. Reversing lever plunger
10. Table-reversing lever
11. Table stop clamp screw
12. Table stop adjustment screw

F. Parts of footstock (Transparency #8)

1. Footstock dust guard
2. Spindle clamp handle
3. Operating lever
4. Footstock clamp and bolt
5. Center

G. Parts of swivel table adjustment (Transparency #9)

1. Swivel table scale
2. Table clamp bolts
3. Index finger
4. Table clamp
5. Locking-pin knob
6. Adjusting nut

INFORMATION SHEET

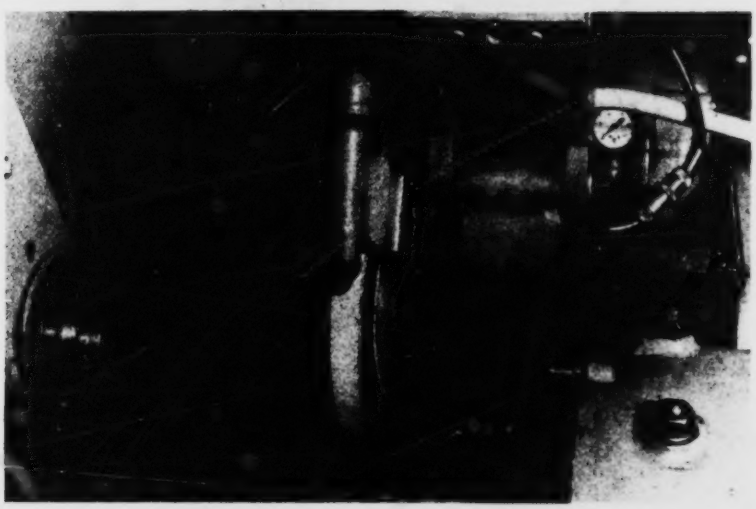
XIII. Methods of applying coolant

A. Flood — Coolant is forced through piping to a nozzle that directs coolant onto wheel at point of contact, thus washing wheel and cooling workpiece; coolant drains back into system and is filtered before being recycled (Figures 14 and 15)

EXAMPLES:

FIGURE 14 Surface Grinder

FIGURE 15 Cylindrical Grinder



INFORMATION SHEET

B. Mist or spray — Small nozzle mixes coolant with air; mixture is blown onto wheel and workpiece; helps clean wheel and cool workpiece, and provides for an unobstructed view of wheel and workpiece (Figure 16)

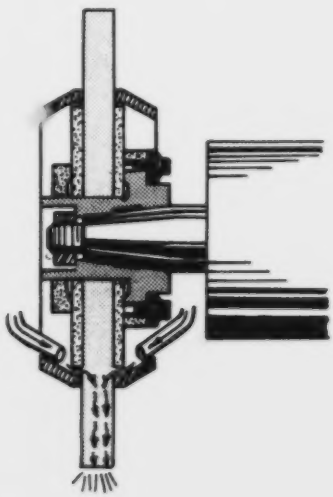
EXAMPLE:

FIGURE 16

C. Through-the-wheel — Coolant is stored in wheel flanges; holes drilled into wheel allow the wheel to absorb coolant to ensure that coolant gets to the wheel/workpiece interface (Figure 17)

(NOTE: The fluid is thrown over the entire inner surface of the guard. This allows dirty coolant to drip onto the workpiece, possibly leading to surface scratches.)

FIGURE 17



INFORMATION SHEET

XIV. Descriptions of grinding operation problems

A. Chatter — Excessive vibration of grinding wheel

B. Burning — Change in workpiece being ground caused by grinding heat; usually results in discoloration of surface

C. Feed lines — Pattern produced on workpiece as a result of table or workpiece movement

D. Scratches — Irregular marks left in surface of workpiece

(NOTE: Various types of scratches may result from specific causes.)

EXAMPLES: Spirals, wavy marks

E. Check marks — Unwanted pattern on workpiece resulting from slowing or stopping of grinding wheel due to excess pressure or friction

F. Hollow spots — Areas on workpiece that have been allowed to heat excessively, causing them to expand and be ground off

G. Explosion — Breaking up of a grinding wheel as a result of turning faster than its maximum safe operating speed or from being improperly stored

XV. Possible causes of grinding operation problems (Assignment Sheet #1)

A. Chatter

1. Wheel out of balance
2. Wheel out of round
3. Wheel too hard
4. Wheel too fine
5. Improperly or poorly dressed wheel
6. Misalignment of centers
7. Work centers not lubricated
8. Work centers damaged or not true
9. Work loose on centers

B. Burnt or discolored finish

1. Cutting pressure too great

2. No coolant (dry grinding)
3. Insufficient coolant
4. Coolant not properly applied
5. Wrong type of coolant
6. Glazed or loaded wheel
7. Wheel too hard
8. Wheel too fine
9. Improperly or poorly dressed wheel
10. Table travel too fast

C. Feed lines

1. Wheel too soft
2. Wheel too coarse
3. Improperly or poorly dressed wheel
4. Ragged wheel edge
5. Improper travel or work speed
6. Worn spot in table ways
7. Misalignment of centers
8. Coolant not properly applied

D. Scratches

1. Wheel too coarse
2. Wheel too soft
3. Improperly or poorly dressed wheel
4. Oil spots on face of wheel
5. Ragged wheel edges
6. Glazed or loaded wheel

INFORMATION SHEET

7. Loose dirt from wheel guard
8. Bond allowing abrasives to be pulled out
9. Dirty coolant
10. Wrong type of coolant

E. Short and long wave marks

1. Wheel out of round
2. Wheel out of balance
3. Internal machine vibrations
4. Vibrations of drive belt
5. Cutting pressure too great
6. Wheel soaked from coolant on one side
7. Work centers not lubricated
8. Oil spots on face of wheel

F. Spirals

1. Worn spot in table ways
2. Misalignment of centers
3. Improperly or poorly dressed wheel
4. Workpiece loose on centers
5. Table travel too fast
6. Vibrations of drive belt
7. Internal machine vibrations

G. Check marks

1. Coolant not properly applied
2. No coolant (dry grinding)
3. Insufficient coolant

4. Improper travel or work speed

5. Cutting pressure too great

6. Glazed or loaded wheel

7. Wheel too hard

XVI. Grinding machine safety (Assignment Sheet #2)

A. Eyes — Wear approved safety glasses or approved eye protection when performing any type of grinding operation

B. Guards — Never operate grinding machines with safety guards removed

C. Hands — Keep hands away from revolving wheel and workpiece during grinding

D. Ring test — Ring test all grinding wheels before mounting

E. Handling — Handle all grinding wheels carefully; use rubber hose over hoist cables when handling large wheels

F. Storing — Store all straight wheels upright; store cup, dish, and saucer wheels flat with cardboard between layers

G. Force — Never force a grinding wheel on a machine spindle

H. Operating speed — Never exceed manufacturer's maximum allowable operating speed of wheel

I. Mounting flanges — Use mounting flanges of correct diameter and those in good condition so that they apply even pressure to sides of wheel

J. Mounting blotters — Use paper blotters on both sides of wheel so that pressure from flanges is evenly applied to sides of wheel

K. Mounting nut — Tighten mounting nut only tight enough to keep wheel from slipping; excessive tightening may crack wheel

L. Starting — Bring wheels that are at least 12 inches in diameter up to operating speed slowly by jogging start/stop switches; allow wheel to run one minute before using

M. Grinding — Do not force work into wheel

N. Wheel selection — Use correct wheel for material and type of grinding being done

INFORMATION SHEET

O. Wet grinding — Turn off coolant and allow wheel to run several minutes to remove excess coolant

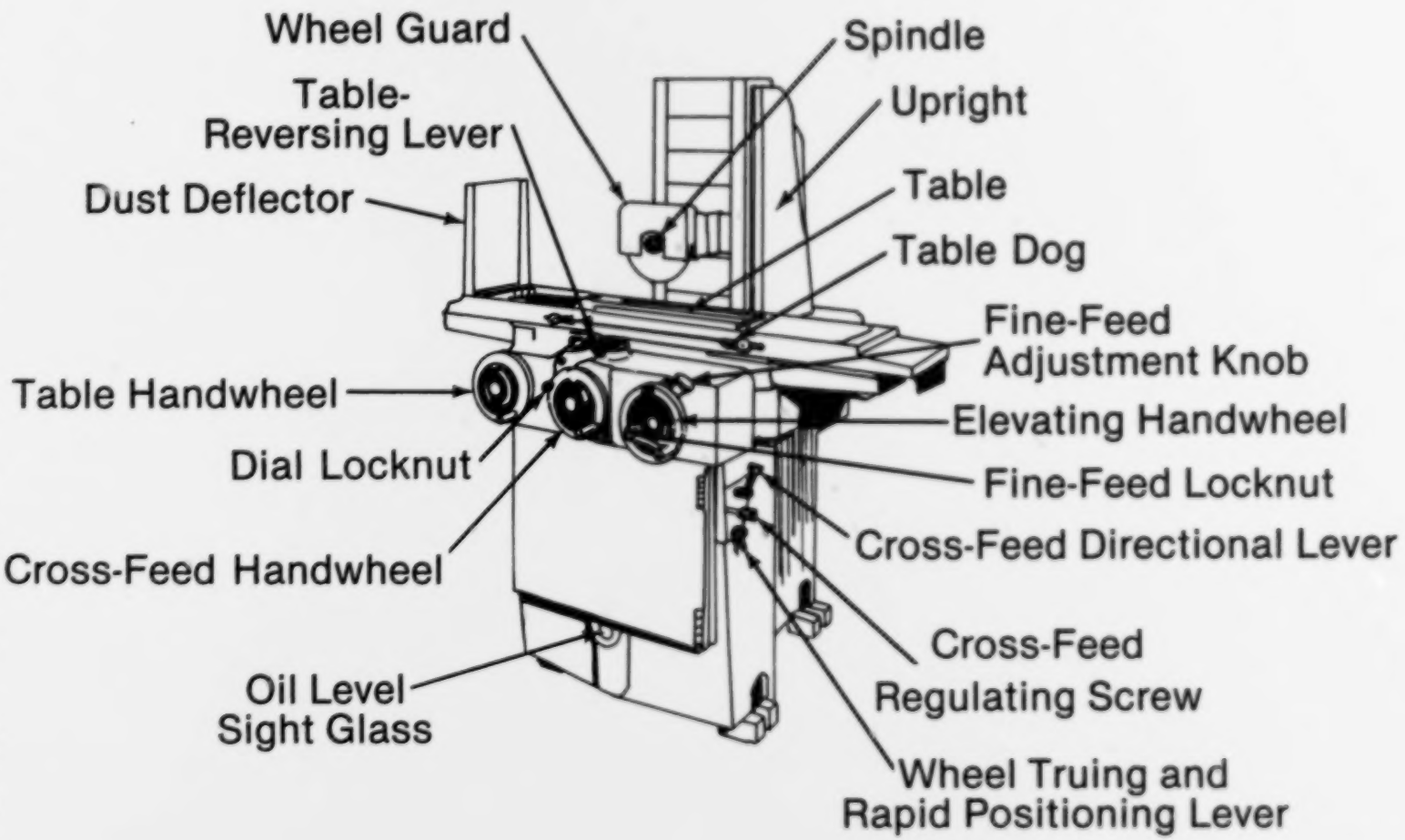
P. Work — Mount and secure workpiece properly; adjust workpiece between centers carefully

Q. Trip dogs — Set trip dogs with care to avoid contact between wheel and machine

R. Dressing — Tilt fixed dressing tools 3 degrees in direction of rotation and slightly left of or below center

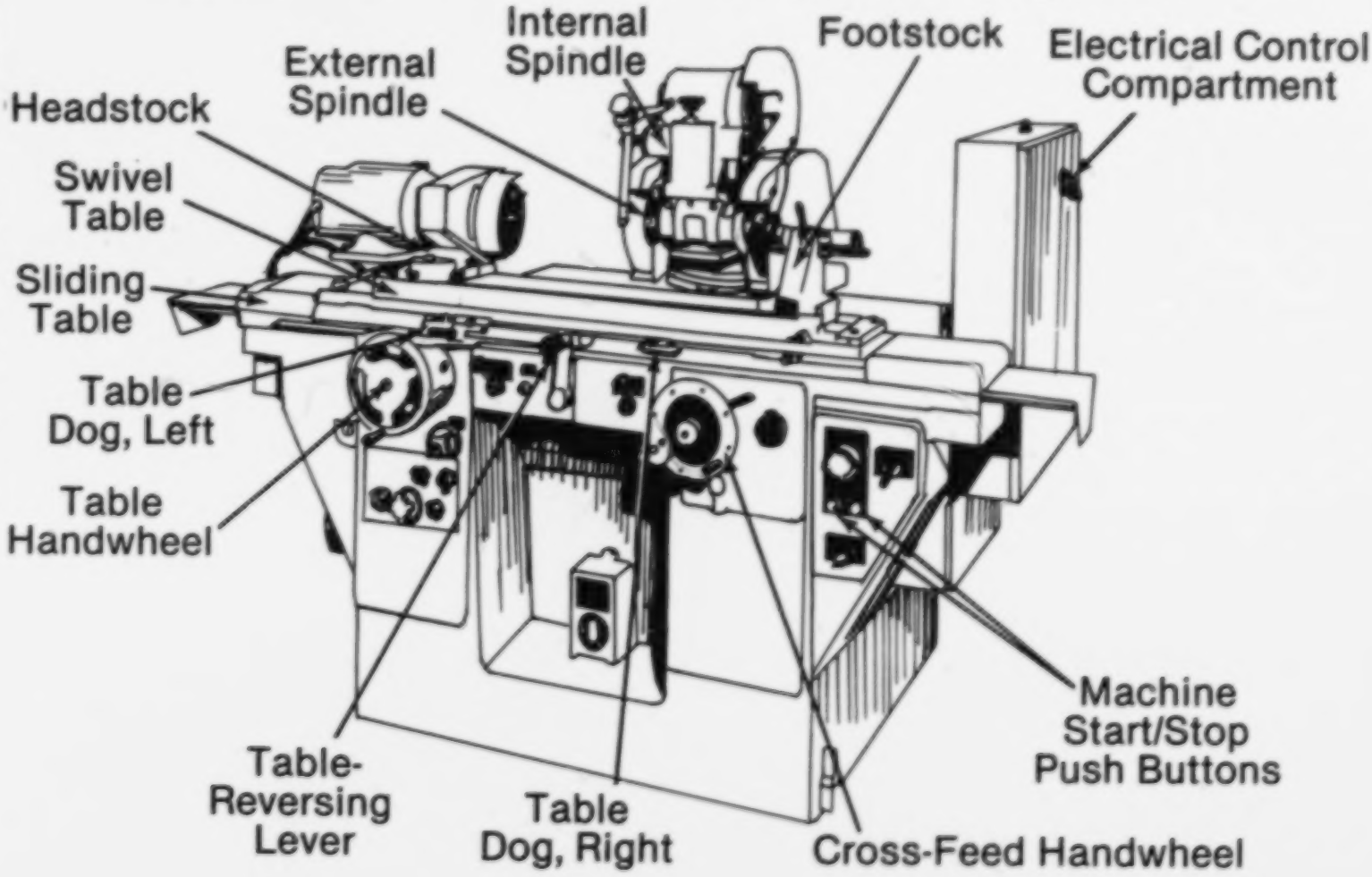
S. Centers — Lubricate center holes of workpiece with a compound other than lead to prevent damage to centers

Parts of a Surface Grinder



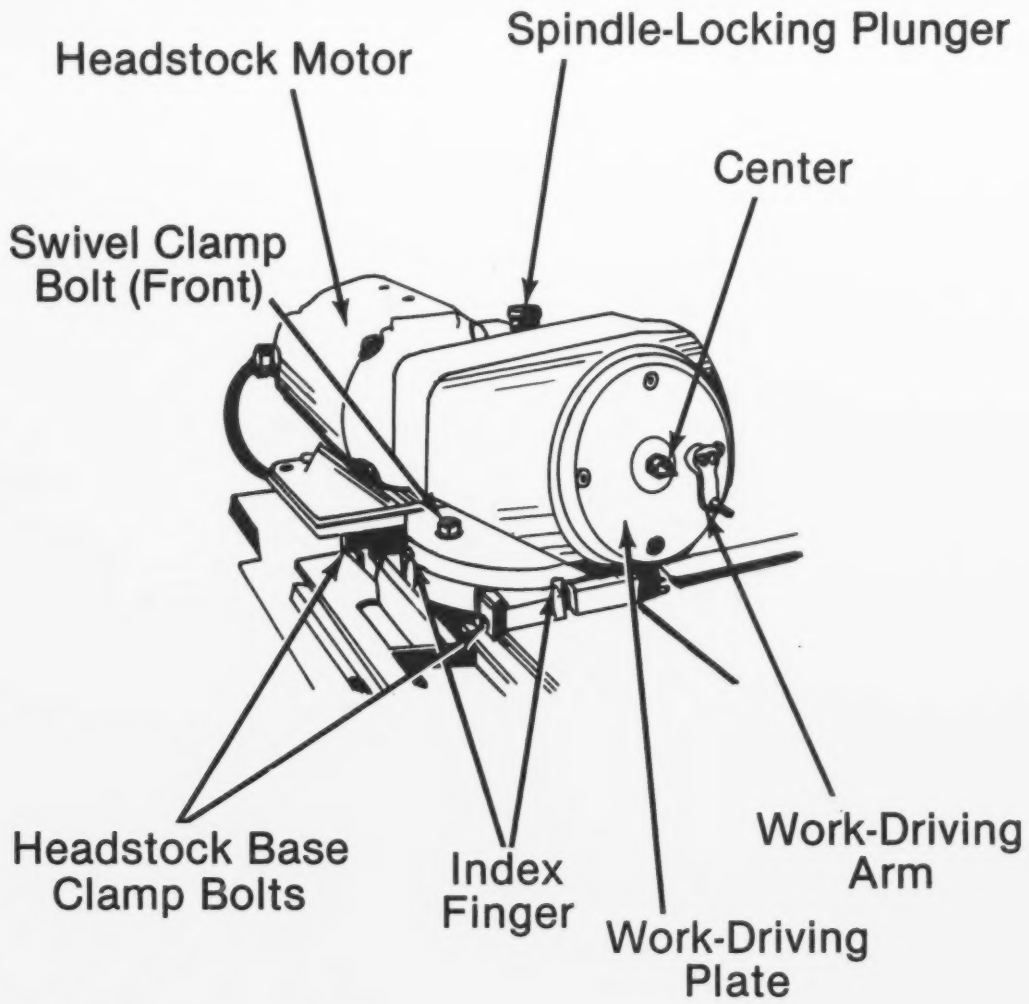
Source: Operation and Maintenance of the 618 Micromaster Surface Grinding Machines, Brown and Sharpe Manufacturing Company.

Major Parts of a Cylindrical (Universal) Grinder



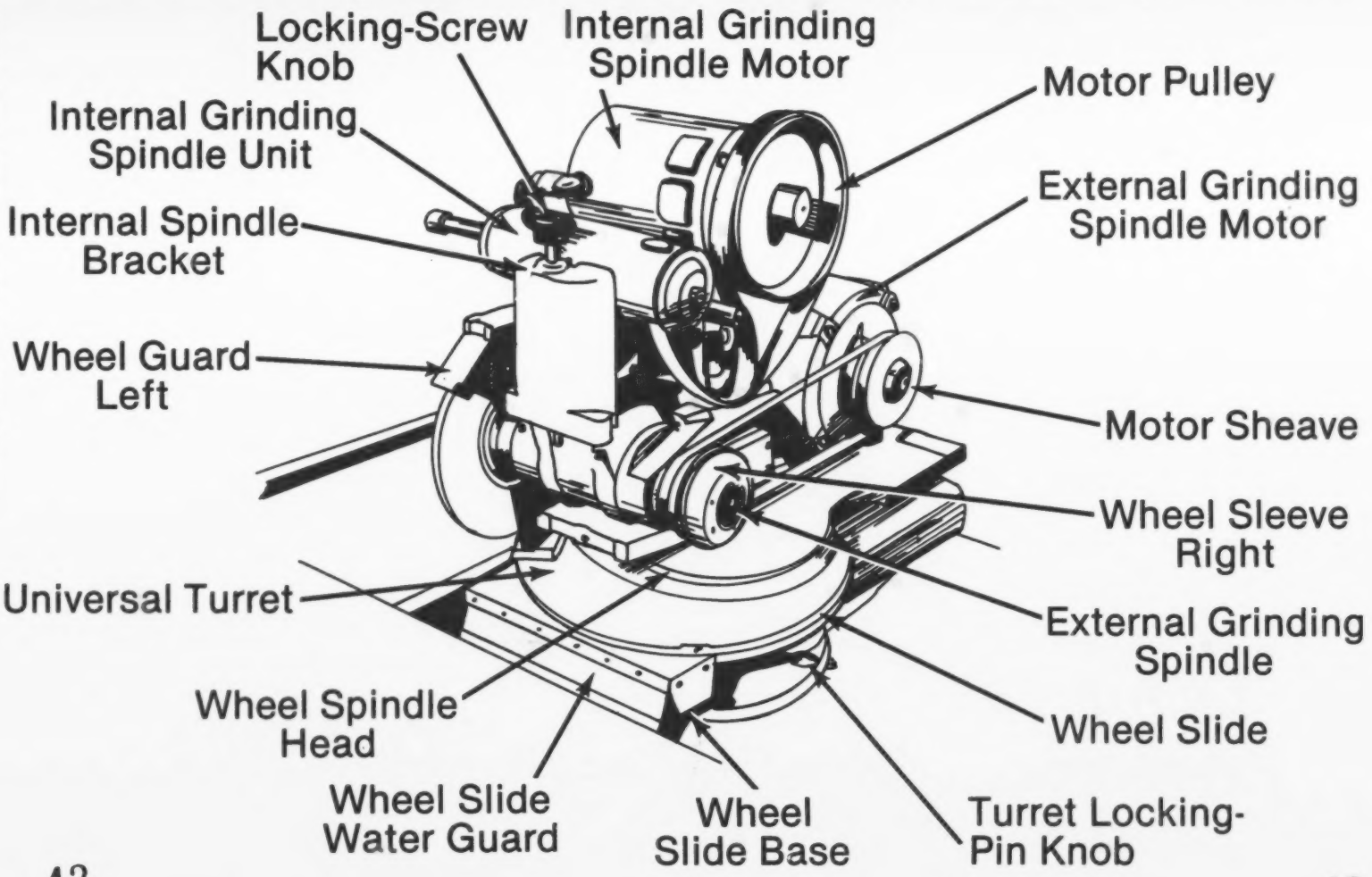
Used with permission of Brown and Sharpe Manufacturing Company.

Parts of the Headstock of a Cylindrical (Universal) Grinder



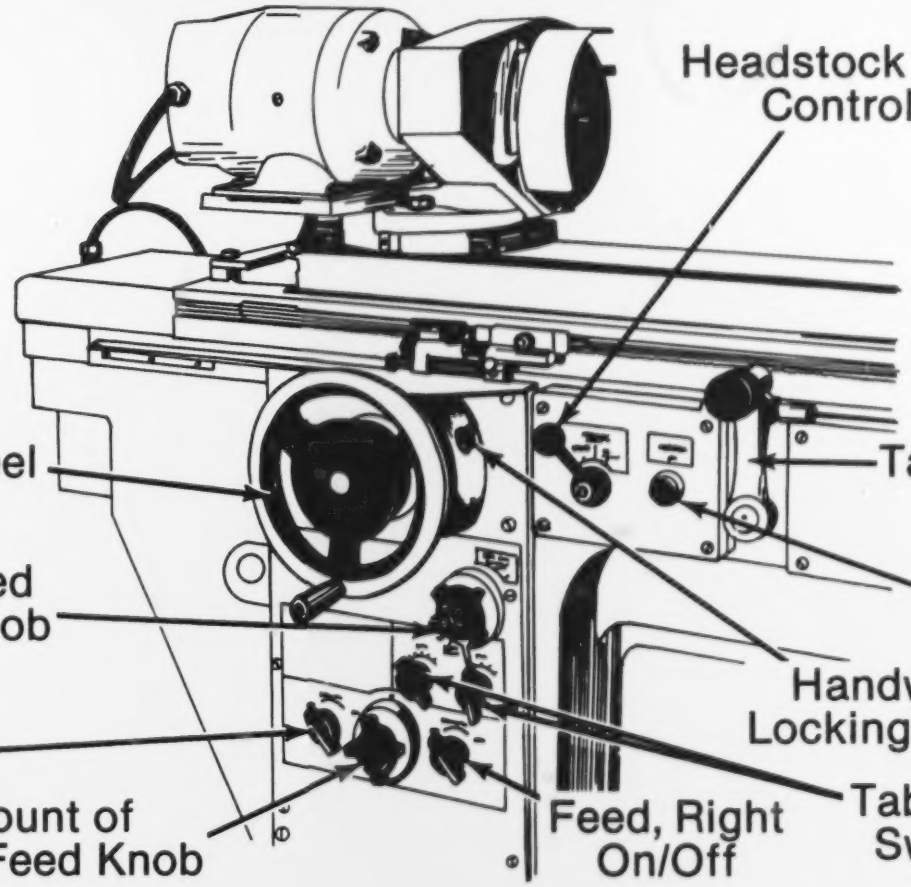
Used with permission of Brown and Sharpe Manufacturing Company.

Parts of the Upright of a Cylindrical (Universal) Grinder



Used with permission of Brown and Sharpe Manufacturing Company.

Cylindrical (Universal) Grinder
Controls on Left Front of Machine



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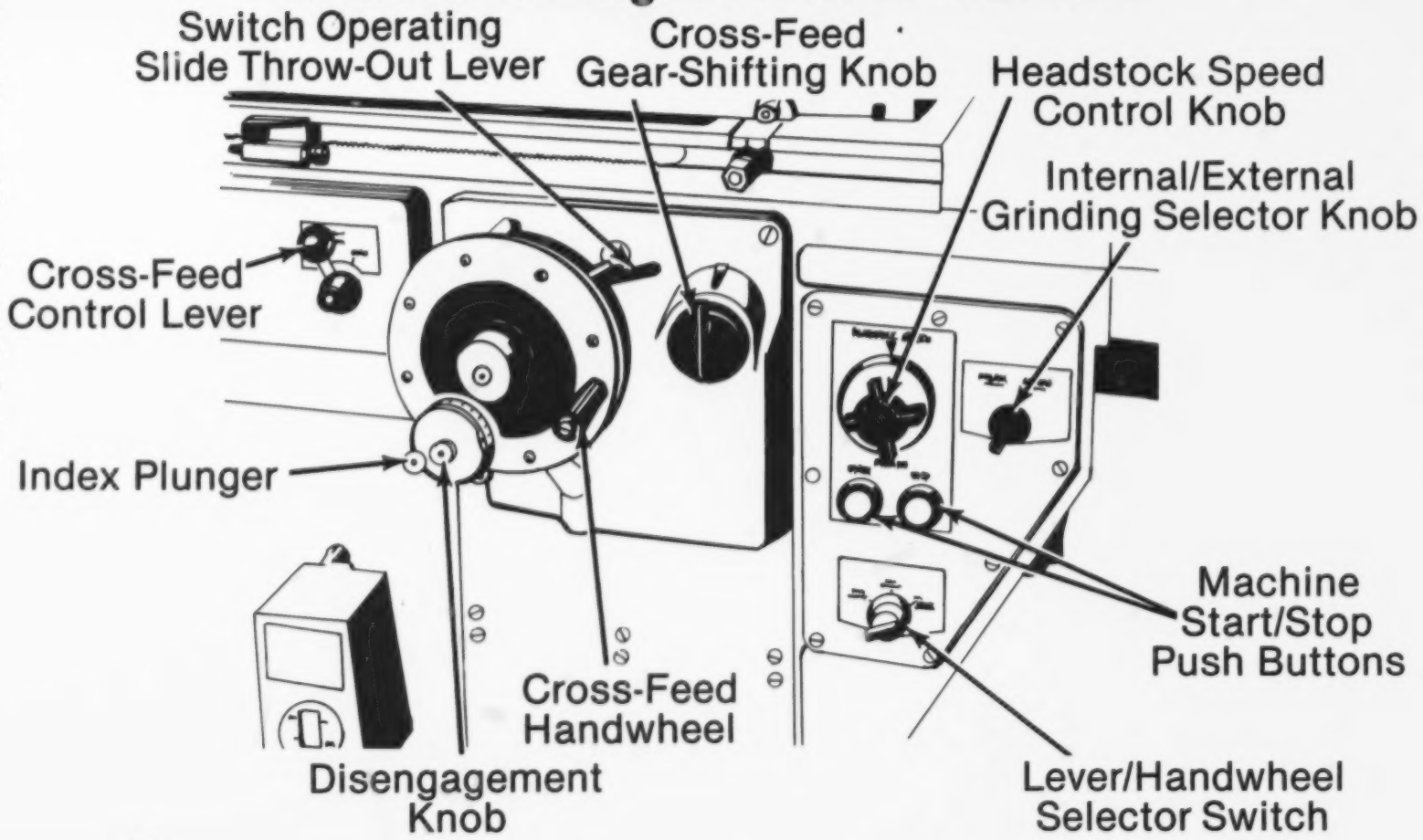
Cylindrical (Universal) Grinder Controls on Right Front of Machine



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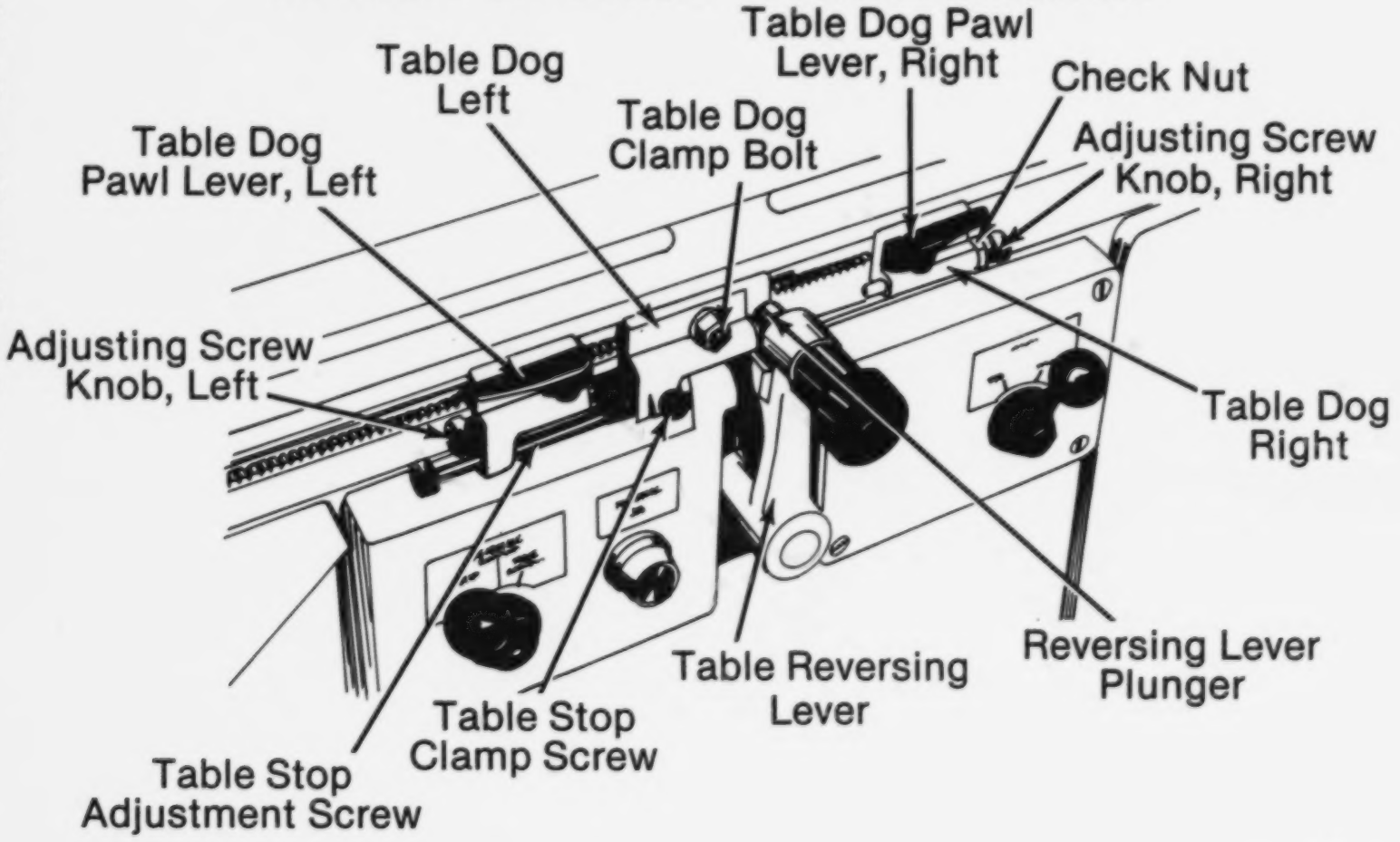
Cylindrical (Universal) Grinder
Controls on Center Front of Machine



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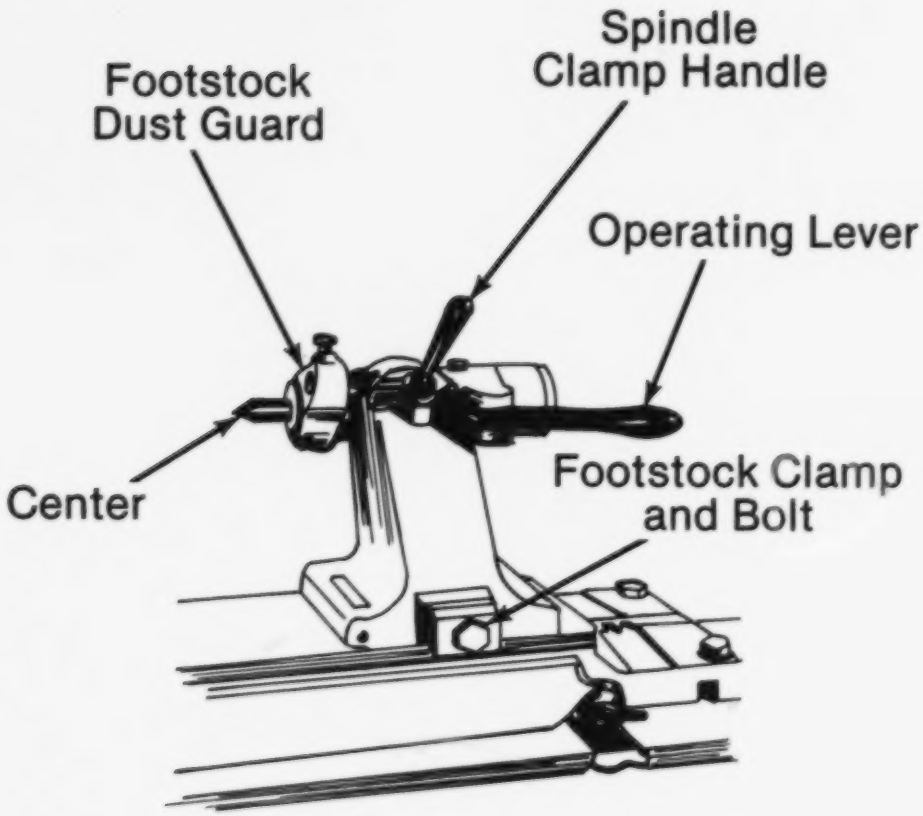
Parts of the Footstock of a Cylindrical (Universal) Grinder



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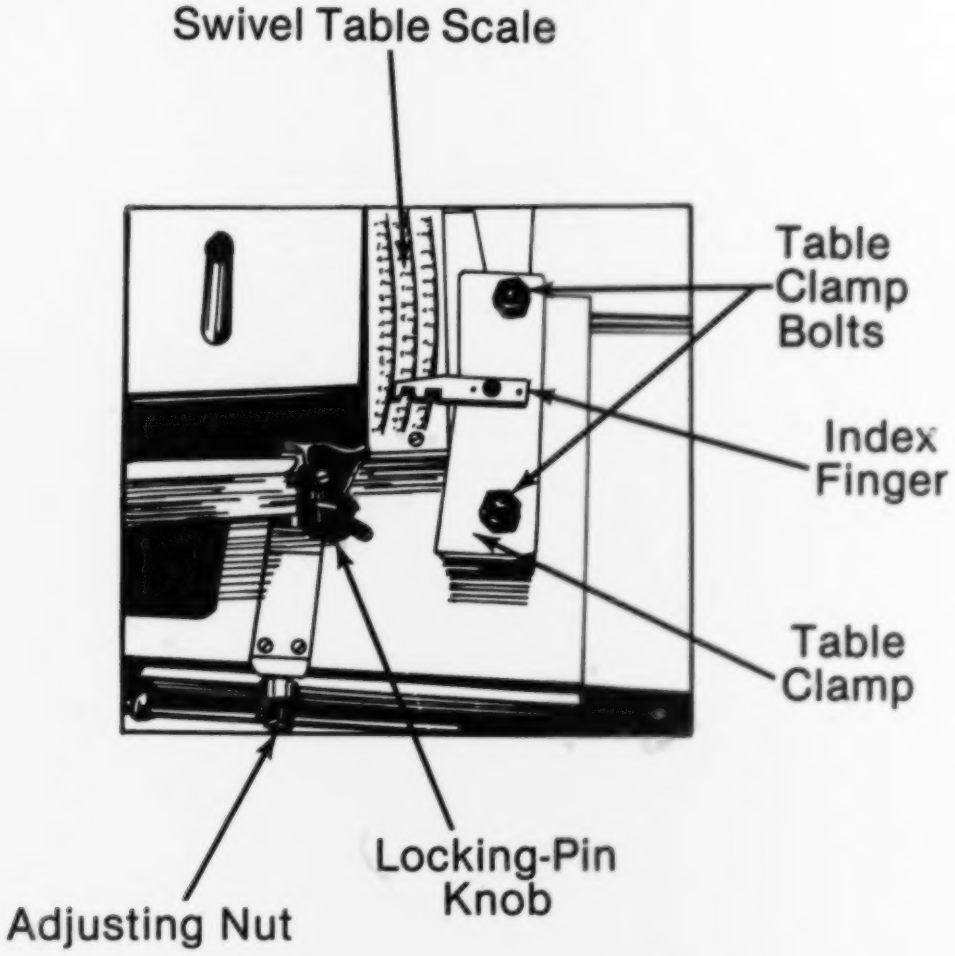
Parts of the Swivel Table Adjustment



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GRINDING MACHINES
UNIT I

ASSIGNMENT SHEET #1 — IDENTIFY CAUSES OF GRINDING PROBLEMS

NAME _____ SCORE _____

Grinding operations greatly affect the shape and finish of the workpiece. Therefore, it is essential that the efficient grinding machine operator be aware of problems that can lead to damaging the work beyond recovery. Once the problem has been recognized, the operator must be able to determine the cause of the problem and take action to correct it before it is too late.

Write an "X" before those conditions listed that might cause the problem.

PROBLEM		POSSIBLE CAUSE
A.	Chatter	_____ 1. Improperly or poorly dressed wheel
		_____ 2. Work centers not lubricated
		_____ 3. Wheel too soft
		_____ 4. Wheel too coarse
		_____ 5. Wheel out of balance
		_____ 6. Misalignment of centers
		_____ 7. Work centers damaged or not true
		_____ 8. Wheel out of round
		_____ 9. Work mounted true on centers
		_____10. Work loose on centers
B.	Scratches	_____ 1. Wheel too fine
		_____ 2. Wheel too hard
		_____ 3. Improperly or poorly dressed wheel
		_____ 4. Oil spots on face of wheel
		_____ 5. Ragged wheel edges
		_____ 6. Dirty coolant
		_____ 7. Dirt on wheel guard

ASSIGNMENT SHEET #1

_____ 8. Bond allowing abrasives to be pulled out

_____ 9. Glazed or loaded wheel

_____10. Wrong type of coolant

C. Spirals

_____ 1. Worn spot on table

_____ 2. Misalignment of centers

_____ 3. Ragged wheel edges

_____ 4. Improperly or poorly dressed wheel

_____ 5. Centers tight on workpiece

_____ 6. Vibrations of drive belt

_____ 7. Table travel too slow

_____ 8. Wrong type of coolant

_____ 9. Internal machine vibrations

_____10. Wheel too hard

D. Check marks

_____ 1. Coolant not properly applied

_____ 2. Too much coolant

_____ 3. Grit too fine

_____ 4. Wheel too soft

_____ 5. No coolant (dry grinding)

_____ 6. Improperly or poorly dressed wheel

_____ 7. Cutting pressure too great

_____ 8. Improper travel or work speed

_____ 9. Glazed or loaded wheel

_____10. Work not properly secured

ASSIGNMENT SHEET #1

E. Short and long wave marks

_____ 1. Wheel out of round
_____ 2. Vibrations of drive belt
_____ 3. Wheel speed too fast
_____ 4. Internal machine vibrations
_____ 5. Not enough cutting pressure
_____ 6. Wheel out of balance
_____ 7. Insufficient coolant
_____ 8. Work centers not lubricated
_____ 9. Oil spots on face of wheel
_____10. Incorrect arbor size

F. Feed lines

_____ 1. Wheel too hard
_____ 2. Improperly or poorly dressed wheel
_____ 3. Improper travel or work speed
_____ 4. Wheel out of round
_____ 5. Worn spot in table ways
_____ 6. Misalignment of centers
_____ 7. Coolant not properly applied
_____ 8. Wheel too fine
_____ 9. Ragged wheel edge
_____10. Oil spots on face of wheel

G. Burnt or discolored finish

_____ 1. Cutting pressure too great
_____ 2. No coolant (dry grinding)
_____ 3. Wrong type of coolant
_____ 4. Insufficient coolant

ASSIGNMENT SHEET #1

_____ 5. Wheel too hard

_____ 6. Improperly or poorly dressed wheel

_____ 7. Wheel too coarse

_____ 8. Coolant not properly applied

_____ 9. Glazed or loaded wheel

_____10. Table travel too slow

GRINDING MACHINES
UNIT I

ASSIGNMENT SHEET #2 — STATE RULES FOR SAFE USE OF GRINDING MACHINES

NAME _____ SCORE _____

No machining job can be done effectively and well unless it is done safely. Abrasive action and high speeds, as well as the many operating restrictions involved in grinding procedures, make it critically important that safety practices be observed.

State rules for the safe use of grinding machines by telling how each of the following words or phrases apply to grinding safety.

(NOTE: A score of 100 percent is required for this assignment sheet.)

A. Eyes — _____

_____

_____

B. Guards — _____

_____

_____

C. Hands — _____

_____

_____

D. Ring test — _____

_____

_____

E. Handling — _____

_____

_____

ASSIGNMENT SHEET #2

F. Storing — _____

_____

_____

G. Force — _____

_____

_____

H. Operating speed — _____

_____

_____

I. Mounting flanges — _____

_____

_____

J. Mounting blotters — _____

_____

_____

K. Mounting nut — _____

_____

_____

L. Starting — _____

_____

_____

M. Grinding — _____

_____

_____

ASSIGNMENT SHEET #2

N. Wheel selection — _____

_____

_____

O. Wet grinding — _____

_____

_____

P. Work — _____

_____

_____

Q. Trip dogs — _____

_____

_____

R. Dressing — _____

_____

_____

S. Centers — _____

_____

_____

GRINDING MACHINES
UNIT I

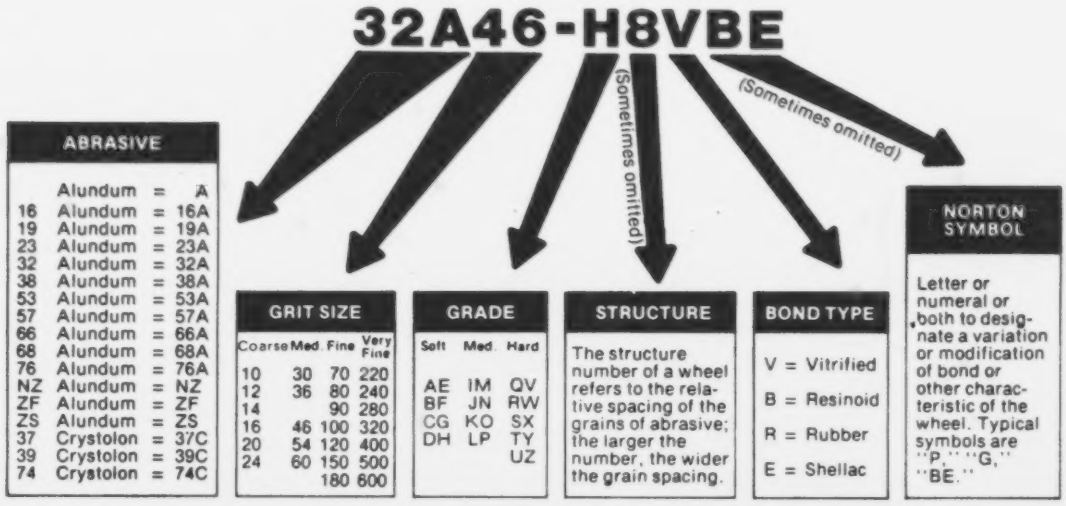
ASSIGNMENT SHEET #3 — INTERPRET GRINDING WHEEL MARKINGS

NAME _____ SCORE _____

The many different materials used and the various types of grinding operations place varied demands on the grinding wheel. For this reason, it is important that a wheel of the right composition be used, including the correct abrasive, grit size, and bond type. The machinist must be able to interpret grinding wheel markings to know the composition of wheels in order to select the proper grinding wheel.

Use the chart below to interpret the following grinding wheel markings.

NON-DIAMOND GRINDING WHEELS



ABRASIVE

	Alundum	= A
16	Alundum	= 16A
19	Alundum	= 19A
23	Alundum	= 23A
32	Alundum	= 32A
38	Alundum	= 38A
53	Alundum	= 53A
57	Alundum	= 57A
66	Alundum	= 66A
68	Alundum	= 68A
76	Alundum	= 76A
NZ	Alundum	= NZ
ZF	Alundum	= ZF
ZS	Alundum	= ZS
37	Crystolon	= 37C
39	Crystolon	= 39C
74	Crystolon	= 74C

GRIT SIZE

Coarse	Med.	Fine	Very Fine
10	30	70	220
12	36	80	240
14		90	280
16	46	100	320
20	54	120	400
24	60	150	500
		180	600

GRADE

Soft	Med.	Hard
AE	IM	QV
BF	JN	RW
CG	KO	SX
DH	LP	TY
		UZ

STRUCTURE

The structure number of a wheel refers to the relative spacing of the grains of abrasive; the larger the number, the wider the grain spacing.

BOND TYPE

V = Vitrified
B = Resinoid
R = Rubber
E = Shellac

NORTON SYMBOL

Letter or numeral or both to designate a variation or modification of bond or other characteristic of the wheel. Typical symbols are "P," "G," "BE."

Used with permission of the Norton Company.

A. 32A36-I8VBE

1. Abrasive — _____
2. Grit size — _____
3. Grade — _____
4. Structure (number) — _____
5. Bond type — _____

ASSIGNMENT SHEET #3

B. 39C60-J6VK

1. Abrasive — _____
2. Grit size — _____
3. Grade — _____
4. Structure (number) — _____
5. Bond type — _____

C. NZ46-H8V40

1. Abrasive — _____
2. Grit size — _____
3. Grade — _____
4. Structure (number) — _____
5. Bond type — _____

GRINDING MACHINES
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A. 1, 2, 5, 6, 7, 8, 10

B. 3, 4, 5, 6, 8, 9, 10

C. 2, 4, 6, 9

D. 1, 5, 7, 8, 9

E. 1, 2, 4, 6, 8, 9

F. 2, 3, 5, 6, 7, 9

G. 1, 2, 3, 4, 5, 6, 8, 9

Assignment Sheet #2

A. Eyes — Wear approved safety glasses or approved eye protection when performing any type of grinding operation

B. Guards — Never operate grinding machines with safety guards removed

C. Hands — Keep hands away from revolving wheel and workpiece during grinding

D. Ring test — Ring test all grinding wheels before mounting

E. Handling — Handle all grinding wheels carefully; use rubber hose over hoist cables when handling large wheels

F. Storing — Store all straight wheels upright; store cup, dish, and saucer wheels flat with cardboard between layers

G. Force — Never force a grinding wheel on a machine spindle

H. Operating speed — Never exceed manufacturer's maximum allowable operating speed of wheel

I. Mounting flanges — Use mounting flanges of correct diameter and those in good condition so that they apply even pressure to sides of wheel

J. Mounting blotters — Use paper blotters on both sides of wheel so that pressure from flanges is evenly applied to sides of wheel

ANSWERS TO ASSIGNMENT SHEETS

K. Mounting nut — Tighten mounting nut only tight enough to keep wheel from slipping; excessive tightening may crack wheel

L. Starting — Bring wheels that are at least 12 inches in diameter up to operating speed slowly by jogging start/stop switches; allow wheel to run one minute before using

M. Grinding — Do not force work into wheel

N. Wheel selection — Use correct wheel for material and type of grinding being done

O. Wet grinding — Turn off coolant and allow wheel to run several minutes to remove excess coolant

P. Work — Mount and secure workpiece properly; adjust workpiece between centers carefully

Q. Trip dogs — Set trip dogs with care to avoid contact between wheel and machine

R. Dressing — Tilt fixed dressing tools 3 degrees in direction of rotation and slightly left of or below center

S. Centers — Lubricate center holes of workpiece with a compound other than lead to prevent damage to centers

Assignment Sheet #3

A.
1. 32 Alundum
2. Medium
3. Medium
4. 8
5. Vitrified

B.
1. 39 Crystolon
2. Medium
3. Medium
4. 6
5. Vitrified

ANSWERS TO ASSIGNMENT SHEETS

C.
1. NZ Alundum
2. Medium
3. Soft
4. 8
5. Vitrified

GRINDING MACHINES
UNIT I

JOB SHEET #1 — OPERATE SURFACE GRINDER CONTROLS PROPERLY

(NOTE: The procedures outlined apply to a Brown and Sharpe surface grinder. It may be necessary to modify the job sheet for the type of machine being used.)

I. Equipment and materials

A. Surface grinder with power feed in longitudinal and traversal directions

B. Magnetic chuck (mounted to table)

C. Operator's manual

D. Grease pencil

E. Steel rule, 6"

II. Procedure for manual operation

A. Crank elevating handwheel so that bottom of grinding wheel is 2 inches above top surface of magnetic chuck

(NOTE: Clockwise rotation of the handwheel moves the wheel up.)

B. With left hand, crank table handwheel clockwise and counterclockwise about three or four revolutions in each direction until smooth, continuous movement of table is sustained

C. With right hand, crank cross-feed handwheel clockwise, moving the grinding wheel toward you

D. Crank cross-feed handwheel counterclockwise to move grinding wheel edge over the back of magnetic chuck

(NOTE: The cross feed can be moved in or out with the fine-feed adjustment knob; each graduation is 0.0001 inch. Counterclockwise rotation of the fine-feed adjustment knob moves the wheel toward the table.)

E. Engage fine-feed adjustment knob by tightening fine-feed locknut; turn fine-feed adjustment knob

F. Loosen fine-feed locknut

(NOTE: Before you can use the cross-feed handwheel, you must loosen the fine-feed locknut.)

G. Practice cross feeding ten thousandths of an inch (0.010 inch) by placing cross-feed handwheel so that your thumb contacts with the cross-feed pointer for each 0.010 inch of cross feed travel

H. With left hand, start turning table handwheel about three turns right and left of center; each time just before starting right, move cross feed toward table about 0.010 inch

(NOTE: This movement of table and cross feed should be done with the table moving continuously.)

I. Continue this movement until cross feed has moved about 2 inches

J. Tighten fine-feed locknut

(NOTE: Up or down movement of the grinding wheel is a manual operation. The grinding wheel moves at a rate of 0.0002 inch per graduation on the fine-feed adjustment knob.)

K. Turn fine-feed adjustment knob one revolution clockwise and note movement of elevating handwheel dial

III. Procedure for power movements

A. Use table handwheel to position table so that grinding wheel is centered over magnetic chuck (Figure 18)

FIGURE 18

JOB SHEET #1

B. Raise table so that wheel is 2 inches above chuck

C. Set table dogs on each side of table-reversing lever

D. Loosen adjustment bushing setscrew

E. Move table-reversing lever to the right or left position, and turn table throttle lever until table moves at desired speed

F. Tighten adjustment bushing setscrew

(NOTE: The table handwheel is engaged for manual movement and is automatically disengaged when using power table travel.)

(CAUTION: When setting table dogs for grinding a workpiece, the dogs should be set so that the wheel comes off the workpiece at both ends, allowing step-over to be completed before grinding takes place.)

G. Move table throttle lever to OFF position and put table reversing-lever in NEUTRAL position

H. Turn selector lever to GRIND position for intermittent power cross feed

I. Pull or push cross-feed directional lever and turn throttle lever until it hits set position

J. Adjust amount of cross-feed to desired step-over (0.01 inch to 0.25 inch) by turning cross-feed regulating screw

(NOTE: The intermittent cross feed has no reversing lever; the direction of movement must be reversed manually by pulling or pushing the cross-feed directional lever.)

K. Shut off table throttle lever

L. Position wheel over center of chuck near back edge

M. Start table moving right and left by turning on table throttle lever and placing reversing lever right or left

N. Pull cross-feed directional lever forward and allow wheel to move 1 inch

O. Push cross-feed directional lever back

(NOTE: The amount of step-over can be observed because the dial of the cross feed turns each time step-over is performed.)

P. Stop power feeds

JOB SHEET #1

Q. With the grease pencil, lay out a 5-by-1-inch rectangle in center of magnetic chuck so that the 5-inch length runs parallel to longitudinal feed (Figure 19)

FIGURE 19

R. Set right and left table dogs so that wheel will travel about 1 inch past each end of layout

S. Set table travel at 30 inches per minute and cross feed step-over at 0.015 inch per stroke

T. Have your instructor check your settings and observe your performance

1. Make a pass about 2 inches over top surface of chuck

2. Lower wheel 0.001 inch and make a second pass

U. Repeat setting up and making power movements until your instructor is satisfied with your performance

V. Reset machine and clean marks off chuck

GRINDING MACHINES
UNIT I

JOB SHEET #2 — OPERATE CYLINDRICAL GRINDER CONTROLS PROPERLY FOR MANUAL FEEDS

(NOTE: The procedures described here apply to the Brown and Sharpe #1 Universal Grinder. It may be necessary to modify the job sheet for type of machine being used.)

I. Equipment and materials

A. Universal-type cylindrical grinder with headstock and footstock

B. Operator's manual

C. Wrenches required for machine

II. Procedure

A. Check to see that headstock and table control lever, and cross-feed control lever are both in STOP position

(NOTE: It is a standard safety practice to make sure that all power movement controls are in the STOP or NEUTRAL position before power is turned on.)

B. Turn internal/external grinding selector knob to EXTERNAL GRIND position

C. Jog start machine by pushing machine start/stop push buttons to bring grinding wheel up to speed slowly

(CAUTION: When machine is started, the grinding wheel will begin turning.)

D. Move headstock and table control lever to HEADSTOCK RUNNING position; turn headstock speed control knob to 80 revolutions per minute (rpm)

(NOTE: The rotation of the headstock can be regulated from 60 rpm to 600 rpm. Work speed changes are obtained while machine is running.)

E. Set right and left table dogs 16 inches from each other, each one 8 inches from center of table

F. Crank table handwheel right and left to table dogs; note movement of table

G. Pull up on handwheel shaft-locking plunger knob and push in on table handwheel; move table right and left, noting increased movement of table

H. Lift up switch operating slide throw-out lever and crank cross-feed handwheel three or four revolutions clockwise, moving grinding wheel and wheel unit away from table

JOB SHEET #2

I. Crank cross-feed handwheel counterclockwise two revolutions

J. Push down on the switch operating slide throw-out lever, and crank cross-feed handwheel counterclockwise until pin hits stop

K. Crank cross-feed handwheel clockwise until pin slides over switch operating slide

L. Turn lever handwheel selector switch to HEADSTOCK position; crank cross-feed handwheel counterclockwise to the STOP position

M. Start headstock and coolant

N. Crank handwheel clockwise slowly; note that when pin slides up on switch operating slide, it stops movement of headstock and stops coolant

O. Pull index plunger out and rotate it clockwise three turns

(NOTE: Rotating the index plunger moves the fixed stop to the right and allows the grinding wheel to move closer to the workpiece by 0.012 inch. Each division on the plunger is 0.0001 inch for a total of 0.0004 inch per turn. For large movements, the disengagement knob located in the center of the index dial can be pulled out and the body of the dial rotated.)

P. Turn off coolant valve and allow wheel to run for about one minute to remove coolant from wheel

Q. Stop workhead by moving the headstock and table control lever to the STOP position; push machine stop button in

R. Set machine table stops for 3-inch feed on each side of table-reversing lever

S. Set workhead speed at 100 rpm

T. Turn on coolant

U. Have your instructor check your setup and observe while you start machine and feed wheel by power toward workpiece a total of 0.005 inch in cuts of 0.001 inch

V. Repeat setting up and operating machine until your instructor is satisfied with your performance

W. Turn off coolant and allow excess water to clear from wheel; shut down machine

X. Reset and clean machine

GRINDING MACHINES
UNIT I

JOB SHEET #3 — OPERATE CYLINDRICAL GRINDER CONTROLS PROPERLY FOR POWER FEEDS

(NOTE: The procedures described here apply to the Brown and Sharpe #1 Universal Grinder. It may be necessary to modify the job sheet for type of machine being used.)

I. Equipment and materials

A. Universal-type cylindrical grinder with headstock and footstock

B. Operator's manual

C. Wrenches required for machine

D. Steel rule

E. Grease pencil

II. Procedure

A. Check to see that headstock and table control lever and cross-feed control lever are both in the STOP position

(NOTE: It is a standard safety practice to make sure that all power movement controls are in the STOP or NEUTRAL position before power is turned on.)

B. Turn internal/external grinding selector knob to EXTERNAL GRIND position

C. Set table dogs about 16 inches from each other, each one 8 inches from center of table

D. Turn table handwheel by hand to check that table can move to each dog without causing grinding wheel to strike headstock or footstock; adjust table dogs if necessary

E. Jog start machine by pushing start/stop push buttons to bring grinding wheel up to speed

F. Set table speed selector knob to 80 inches per minute

(NOTE: Headstock speed can be changed while machine is running; however, older machines may have belt-driven heads that must be turned off to change speeds.)

G. Set headstock speed control knob to 60 revolutions per minute (rpm)

(NOTE: Table speed can be changed while table is moving.)

H. Turn lever/handwheel selector switch to LEVER CONTROL position

JOB SHEET #3

I. Move table reversing lever to left or right

J. Move headstock and table control lever to TABLE RUNNING position

(NOTE: The headstock will start revolving and the table will begin moving; however, if the table does not move, pull the table-reversing lever to one side and allow the table to move for about one minute to remove air from lines. If table movement is jerky, air is trapped in the line. Have your instructor show you how to work the air out.)

K. Turn left table dwell to a setting of 1½ seconds and right dwell to 2 seconds

(NOTE: Dwell allows the pressure to be removed from the wheel before the table reverses directions. The dwell time is also used to complete feed movement before table movement occurs, and can be set while machine is running.)

L. Move headstock and table control lever to STOP position

M. Set cross-feed knob to 0.0005 inch of feed

N. Turn the feed left and feed right on/off switches to the ON position

(NOTE: Turning these switches on allows feed to occur at both ends before table reverses directions. Normally only feed right is used, so that grind pressure can be removed during the reverse direction of travel; however, for rough grinding, both feeds can be used.)

O. Push down switch operating slide throw-out lever

(NOTE: This lever must be in down position when using automatic feed so that the fixed stop of the cross-feed handwheel will make contact with the switch operating slide.)

P. Turn cross-feed gear-shifting knob to EXTERNAL position

Q. Crank cross-feed handwheel clockwise until fixed stop depresses switch operating slide; then crank handwheel counterclockwise until fixed stop is in three-o'clock position

R. Move headstock and table control lever to TABLE RUNNING position

S. Move cross-feed control lever to START position

T. Allow automatic operation to continue until fixed stop makes contact with switch operating slide

JOB SHEET #3

U. Move cross-feed control lever to the STOP position and crank cross-feed handwheel clockwise until fixed pin rests on switch operating slide

(NOTE: When the wheel has been moved back one revolution or 0.100 inch, the headstock can be stopped to take measurements, and fine-feed adjustments can be made using the index dial. The cross feed cannot be turned until the cross-feed control lever has been moved to the STOP position.)

V. Move headstock and table control lever to HEADSTOCK RUNNING position and turn coolant on

W. Depress and hold headstock jog button

(NOTE: This will stop the headstock and coolant so that the workpiece may be visually inspected.)

X. Release headstock jog button

(NOTE: The headstock will begin turning and coolant will flow.)

Y. Move headstock and table control lever to STOP position.

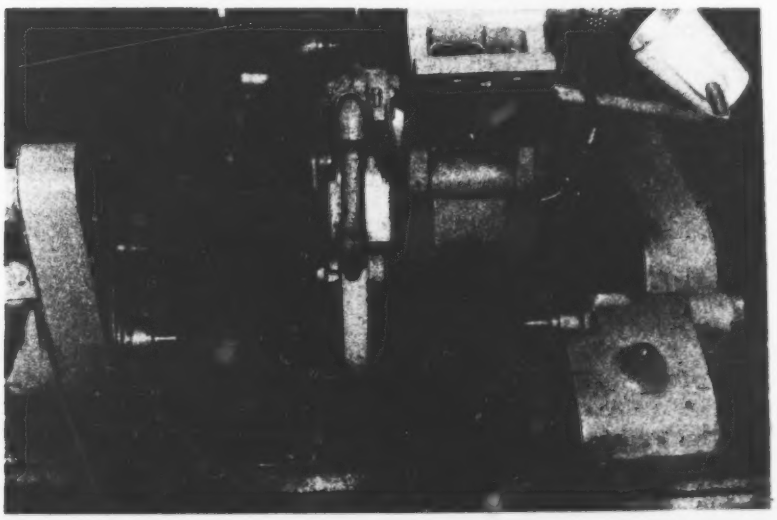
Z. Depress headstock jog button

(NOTE: The headstock will turn when the button is in and stop when the button is released. This button allows the workpiece to be rotated a partial turn by the headstock.)

AA. Push machine stop push button

BB. Set footstock 14 inches from headstock (Figure 20)

FIGURE 20



JOB SHEET #3

CC. Set workhead speed at 80 rpm

DD. Set table speed at 60 inches per minute

EE. Set cross feed at 0.0005 inch per pass, with a one-second dwell left and a two-second dwell right

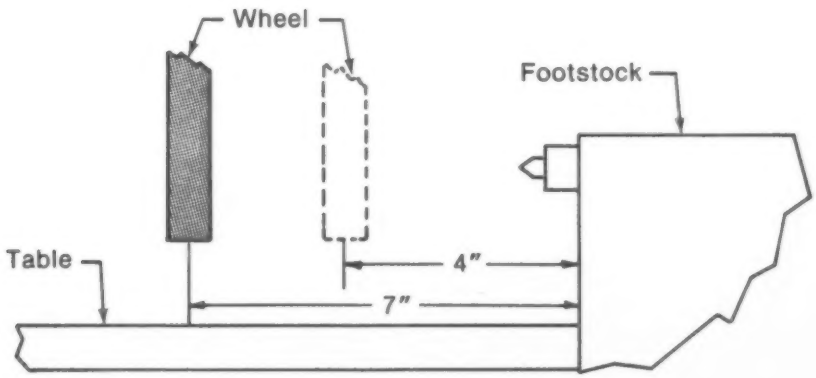
FF. Set cross-feed control right to ON position

(NOTE: With the cross-feed control right on, cross feed will occur when table movement reaches the right.)

GG. Use grease pencil to mark lines on table 4 inches and 7 inches from end of footstock

HH. Set table dogs to trip table-reversing lever when wheel is centered at each line (Figure 21)

FIGURE 21



II. Have instructor check setup and observe your performance

1. Start machine
2. Operate under power to feed wheel 0.005 inch forward
3. Stop cross feed, table, and headstock
4. Turn off coolant and allow wheel to run one minute
5. Shut down machine

JJ. Repeat setting up and operating grinder until instructor is satisfied with your performance

KK. Reset and clean machine

GRINDING MACHINES
UNIT I

JOB SHEET #4 — BALANCE A GRINDING WHEEL

I. Equipment and materials

A. Wheel hub balancing weights and tapered balancing arbor

B. Grinding wheel balancing stand

C. Wrenches to adjust weights

D. Wrenches to mount wheel

E. Chalk

F. Grinding wheel that has been trued

II. Procedure to check for balance

A. Mount balancing arbor in sleeve hole

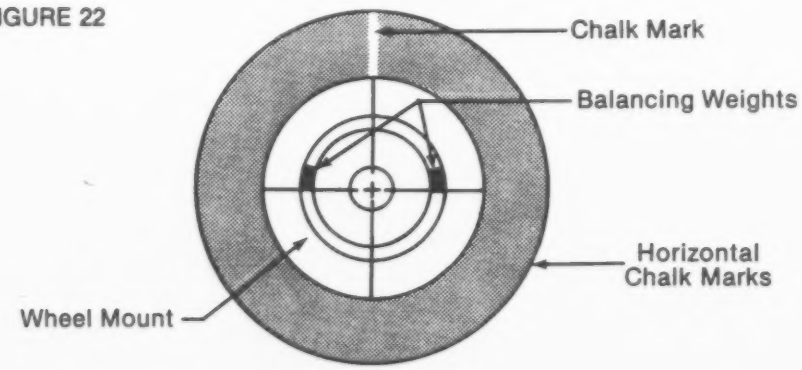
B. Place wheel and balancing arbor on balancing stand; level stand if required

(NOTE: Knife-edge type balancing stands require leveling before balancing; the revolving disk-type does not require leveling.)

C. Rotate wheel and allow it to come to rest

D. Make a chalk mark at top center of grinding wheel (Figure 22)

FIGURE 22



E. Rotate wheel one quarter turn and release

(NOTE: If the wheel moves when released, it needs to be balanced.)

F. Repeat step E for each 90 degrees around wheel

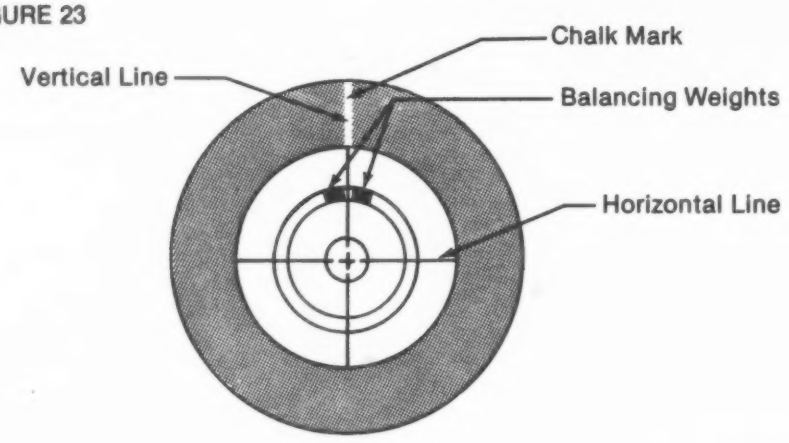
JOB SHEET #4

III. Procedure to balance wheel

A. Loosen setscrews that secure balancing weights in grooved recess of outer flange

B. Move weights at side near chalk mark and tighten setscrews (Figure 23)

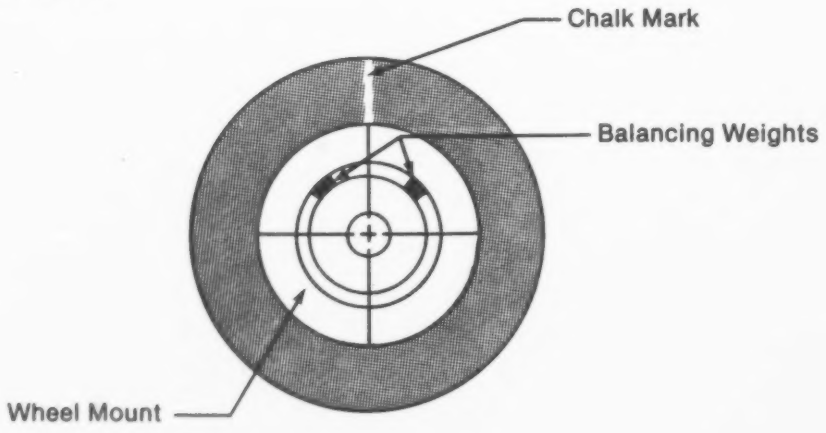
FIGURE 23



C. Check balance

D. If wheel moves from any position, loosen setscrews and move each weight apart an equal distance from position near the chalk mark (Figure 24)

FIGURE 24



JOB SHEET #4

E. Tighten setscrews and recheck balance

F. Continue to move weights apart a little at a time until wheel remains stationary at any position; tighten setscrews

G. Have your instructor check your work

H. Put away all tools

GRINDING MACHINES
UNIT I

JOB SHEET #5 — MOUNT A CHUCK TO HEADSTOCK

I. Equipment and materials

- A. Cylindrical grinder
- B. Chuck that will mount to headstock of grinder (3-jaw or 4-jaw)
- C. Wrench to remove driving plate and mount chuck
- D. Clean cloth
- E. Brass bar, 3/4" by 18"

II. Procedure

- A. Remove four bolts that secure work-driving plate to headstock
- B. Remove work-driving plate
- C. Remove center from headstock
  1. Insert brass rod in spindle
  2. Cup folded cloth over sharp end of center
  3. Tap center gently to break taper of center from housing of headstock
- D. Set spindle for revolving spindle grinding
  1. Withdraw locking plunger
  2. Turn spindle drive latch so that small end will fit into spindle slot
- E. Wipe clean face of headstock
- F. Wipe clean portion of chuck that fits on headstock
- G. Place chuck on headstock so that holes in chuck are in line with tapped holes of headstock
- H. Place bolts through chuck and tighten snugly in alternating pattern
- I. Turn on headstock to check to see that chuck is set to drive
- J. Have instructor check your work and initial this job sheet if performance is satisfactory

GRINDING MACHINES
UNIT I

TEST

NAME _____ SCORE _____

1. Match terms associated with grinding machines to their correct definitions. Write the correct numbers in the blanks. Definitions are continued on the next page.

_____a.	Dulling of cutting particles of grinding wheel; results in decreased cutting efficiency	1. Loaded
_____b.	Turned-over edge of metal caused by grinding operation	2. Profilometer
_____c.	Rate at which workpiece or table traverse is moving; measured in feet per minute	3. Balancing
_____d.	Process to improve or alter cutting action of grinding wheel	4. Work speed
_____e.	Increased temperature of workpiece and wheel caused by friction of grinding	5. Glazing
_____f.	Adding, subtracting, or positioning weights on grinding wheel hub so that wheel weight will be evenly distributed	6. Wheel traverse speed
_____g.	Operation using bonded abrasive stick in special holder to remove stock and produce a desired surface accuracy	7. Burr
_____h.	Condition of grinding wheel in which the pores are filled with material being ground; results in poor finish on workpiece and reduced cutting action of wheel	8. Generated heat
_____i.	Speed of revolving grinding wheel expressed in revolutions per minute (rpm) or surface feet per minute (sfm)	9. Medium
_____j.	Solution used to carry or suspend abrasive particles during lapping operations; plural, *media*	10. Dressing
_____k.	Black layer on surface of steel that has been heat-treated or formed hot; must be removed before grinding	11. Cutter
		12. Honing
		13. Scale
		14. Operating or wheel speed

TEST

_____l. Rate of movement of grinding wheel across workpiece

_____m. Part of grinding wheel dresser that comes into contact with wheel and does the dressing or shaping

_____n. Instrument for measuring the degree of surface roughness in microinches (0.000001 inch)

2. Match grinding machine operations to their correct descriptions. Write the correct numbers in the blanks.

_____a. Finishing process that uses loose abrasive grains carried by a medium to produce a desired surface finish

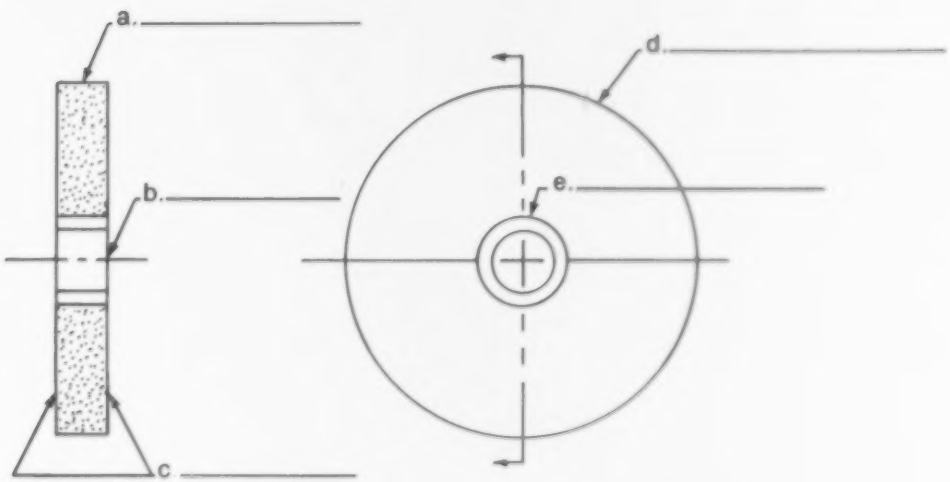
_____b. Final grinding operation to improve dimensional accuracy and obtain desired or near desired finish

_____c. First grinding operation to reduce stock rapidly without particular regard to finish produced

_____d. Process of grinding the gates, fins, and spurs from castings

1. Snagging
2. Finish grinding
3. Rough grinding
4. Lapping

3. Label the parts of a grinding wheel.



TEST

4. Match grinding wheel types to their common applications. Write the correct numbers in the blanks.

_____a.	Straight wheel recessed on both sides; used primarily for surface and cylindrical grinding machine operations	1. Type #1
_____b.	Straight wheel recessed on one side so that greater wheel thickness can be used; used primarily for surface, cylindrical, and off-hand grinding machine operations	2. Type #11
_____c.	Straight wheel used for surface, internal, cylindrical, and offhand grinding machine operations	3. Type #7
_____d.	Dish wheel designed for side grinding with periphery grinding possible; used primarily for toolroom grinding because its thinness permits grinding in narrow places	4. Type #12
_____e.	Flaring-cup wheel designed for side grinding and used primarily for tool and cutter grinding	5. Type #5
_____f.	Straight-cup wheel designed for side grinding and used primarily for cutter grinding; large sizes of this type are used on vertical spindle grinders	6. Type #6

5. Match grinding wheel compositions to their correct descriptions. Write the correct numbers in the blanks.

_____a.	Strength of the bond that holds wheel abrasives together; determines rate at which wheel will break down; designated by letters from A (soft) to Z (hard)	1. Abrasive
_____b.	Material that holds abrasive together; designated by a letter or letters and/or numbers	2. Grade
_____c.	Grain spacing designated by a number from 1 to 12; the higher the number, the more "open" the structure	3. Grain or grit
_____d.	Material in the grinding wheel that acts as the cutting agent; designated with numbers and letters, with the letters identifying the main base	4. Bond
_____e.	Size of abrasive expressed as a number from 10 (coarse) to 600 (very fine)	5. Structure

TEST

6. Name reasons for truing and balancing grinding wheels.

   a. _____

   b. _____

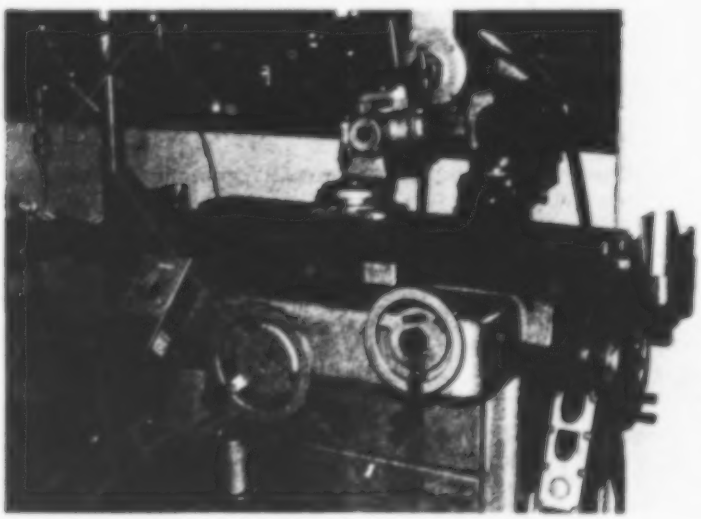
   c. _____

   d. _____

   e. _____

7. Identify types of abrasive cutting machines. Write the correct names in the blanks.

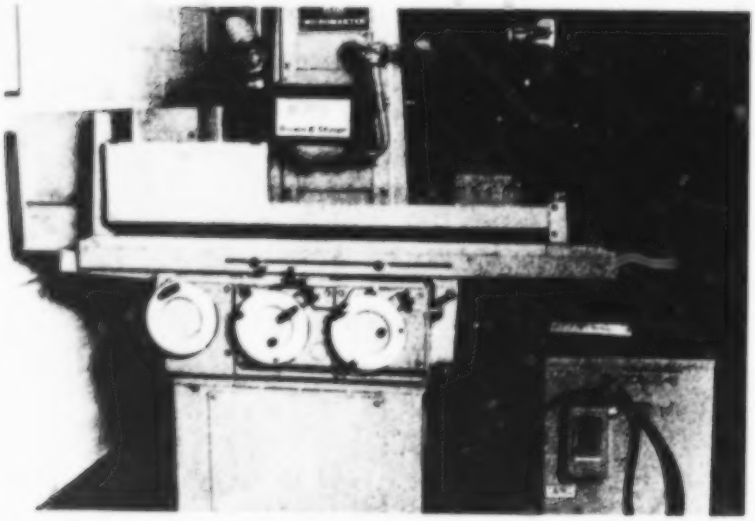
Internal/external grinder
Surface grinder
Universal grinder
Universal and tool grinder



a. _____

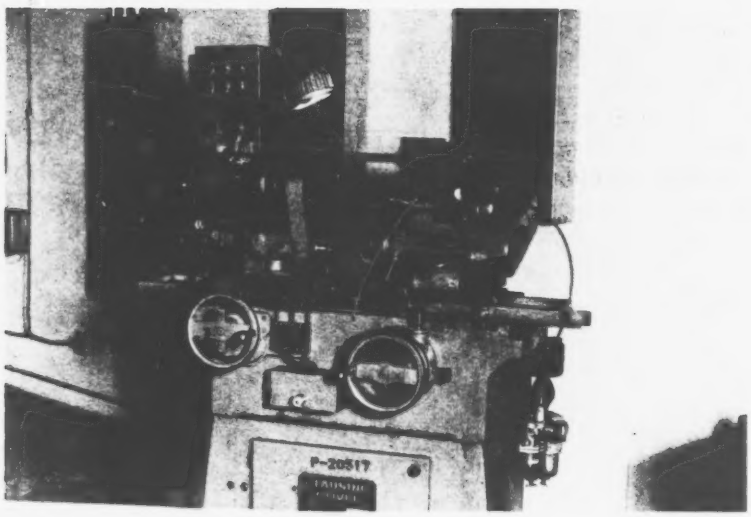
TEST

b. _____



c. _____

TEST

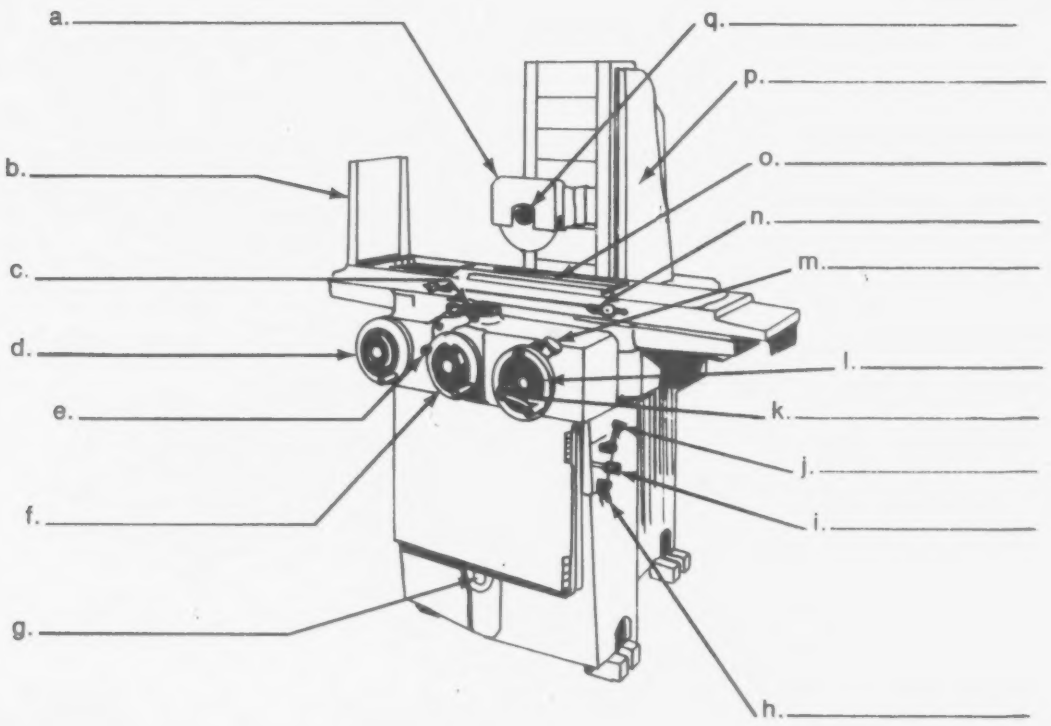


d. _____

TEST

8. Identify the parts of a surface grinder. Write the correct names in the blanks.

Wheel guard
Dust deflector
Dial locknut
Oil level sight glass
Cross-feed regulating screw
Cross-feed directional lever
Elevating handwheel
Fine-feed adjustment knob
Table
Table-reversing lever
Table handwheel
Cross-feed handwheel
Wheel truing and rapid positioning lever
Upright
Fine-feed locknut
Table dog
Spindle



TEST

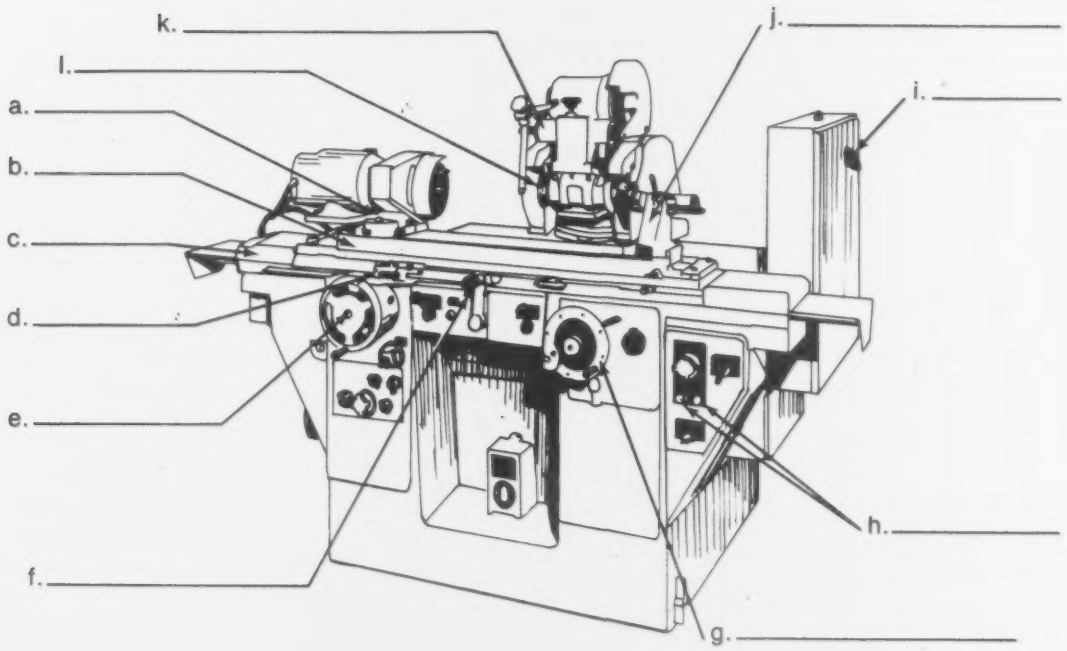
9. Match parts of a surface grinder to their correct functions. Write the correct numbers in the blanks.

_____a.	Allows visual inspection of oil level	1. Upright
_____b.	Houses motor, spindle, and elevating mechanism; moves in and out on ways by means of cross-feed regulating screw	2. Cross-feed handwheel
_____c.	Allows outer graduated ring of cross-feed or elevating wheel to be moved or set without moving feed mechanism	3. Table-reversing lever
_____d.	Regulate length of table travel by tripping table-reversing lever	4. Dial locknut
_____e.	Moves upright in and out, overrides the feed setting, and moves at a set rapid rate	5. Spindle
_____f.	Provides rapid movement of spindle up and down	6. Elevating handwheel
_____g.	Changes direction of table when moving right or left by power feed	7. Wheel guard
_____h.	Engages power-feed mechanism and allows upright to move in or out by power	8. Cross-feed regulating screw
_____i.	Regulates amount of step-over for each cut the wheel makes	9. Table handwheel
_____j.	Raises and lowers elevating mechanism of spindle; each graduation is 0.0002 inch	10. Table
_____k.	Aligns grinding wheel mounting hub and secures hub so that it will run true	11. Fine-feed adjustment knob
_____l.	Moves upright toward and away from table	12. Oil level sight glass
_____m.	Provides a flat surface to which workpiece or work-holding devices are mounted	13. Table dogs
_____n.	Moves table right or left	14. Dust deflector
_____o.	Shields user from dust and chipped particles from wheel or workpiece	15. Wheel truing and rapid positioning lever
_____p.	When tightened, engages fine-feed adjustment knob; when loose, allows rapid movement by handwheels	16. Fine-feed locknut
_____q.	Helps control grinding dust and serves as protective guard in the event that grinding wheel explodes	17. Cross-feed directional lever

TEST

10. Identify major parts of a cylindrical grinder. Write the correct names in the blanks.

Headstock
Internal spindle
Electrical control compartment
Footstock
External spindle
Machine start/stop push buttons
Cross-feed handwheel
Table handwheel
Sliding table
Table dog
Table-reversing lever
Swivel table



TEST

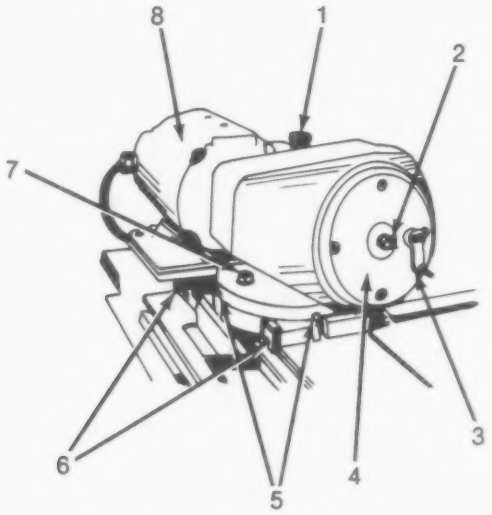
11. Match major parts of a cylindrical grinder to their correct functions. Write the correct numbers in the blanks.

_____a.	Regulate direction of table movement by striking table-reversing lever as table moves by power feed	1. Table-reversing lever
_____b.	Holds wheel and wheel hub for external grinding	2. Swivel table
_____c.	Main part of table; moves right and left by power or manual feed; carries swivel table	3. Headstock
_____d.	Holds workpiece when set up between centers	4. Machine start/stop push buttons
_____e.	Houses main power controls for all electrical components	5. Table dogs
_____f.	Start external spindle and provide power to other controls	6. External spindle
_____g.	Top part of sliding table; has T-slot for mounting work-holding devices or wheel dresser; adjustable to allow grinding of tapers	7. Footstock
_____h.	Reverses direction of sliding table when table is under power feed	8. Internal spindle
_____i.	Supports workpiece and revolves workpiece at set surface feet per minute rate	9. Cross-feed handwheel
_____j.	Holds internal quill and wheels for grinding	10. Electrical control compartment
_____k.	Moves upright in (toward table) or out (away from table) by manual feed	11. Table handwheel
_____l.	Moves sliding table right and left by manual feed	12. Sliding table

TEST

12. Identify selected controls and components of a cylindrical grinder. Write the correct numbers in the blanks.

Headstock



_____a. Headstock base clamp bolts

_____b. Work-driving plate

_____c. Spindle-locking plunger

_____d. Swivel clamp bolt

_____e. Center

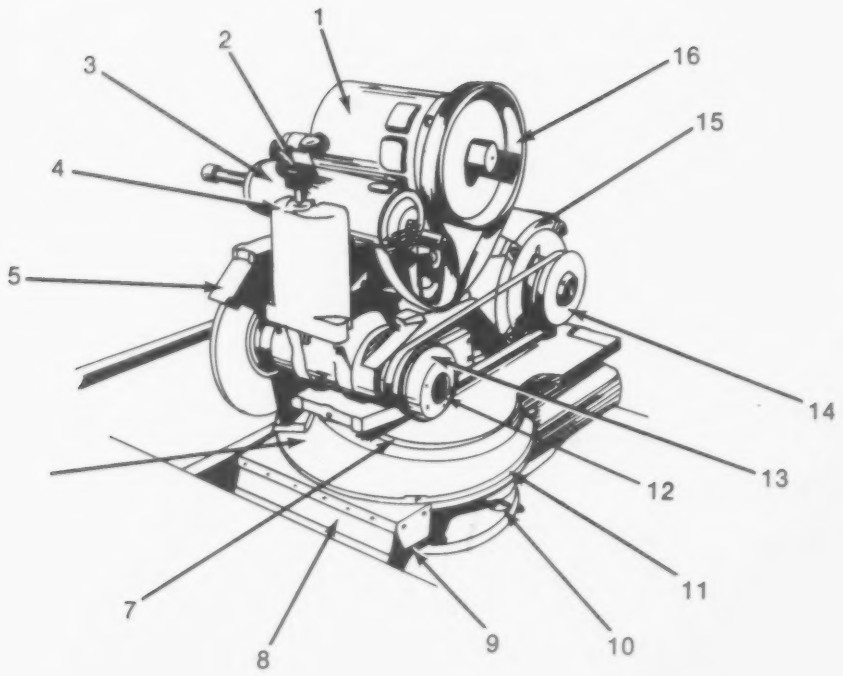
_____f. Headstock motor

_____g. Work-driving arm

_____h. Index finger

TEST

Upright



_____a. Motor pulley

_____b. Wheel sleeve, right

_____c. Locking-screw knob

_____d. Universal turret

_____e. Internal grinding spindle unit

_____f. Motor sheave

_____g. Wheel slide base

_____h. Internal spindle bracket

_____i. Wheel spindle head

_____j. Wheel slide

_____k. External grinding spindle motor

_____l. Turret locking-pin knob

_____m. Internal grinding spindle motor

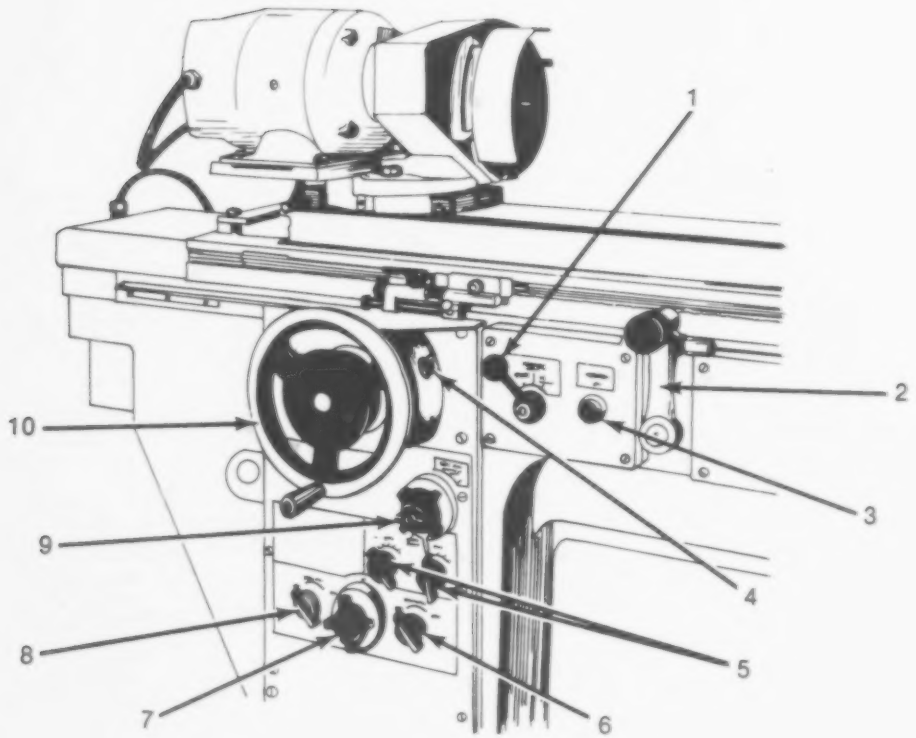
_____n. External grinding spindle

_____o. Wheel slide water guard

_____p. Wheel guard, left

TEST

Controls on left front of machine



_____a. Feed, left on/off

_____b. Table handwheel

_____c. Table-reversing lever

_____d. Feed, right on/off

_____e. Headstock and table control lever

_____f. Handwheel shaft-locking plunger knob

_____g. Table dwell switches

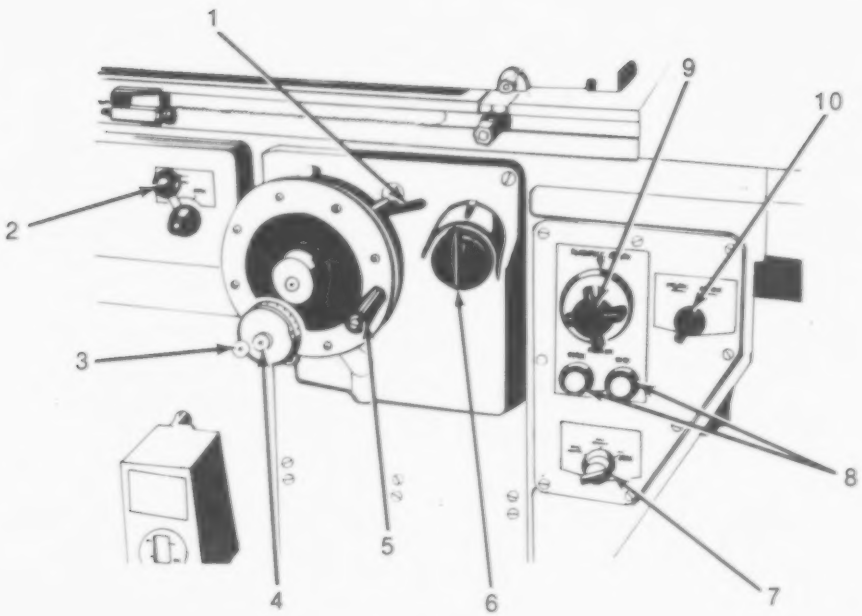
_____h. Amount of cross-feed knob

_____i. Headstock jog button

_____j. Table speed selector knob

TEST

Controls on right front of machine



_____a. Index plunger

_____b. Cross-feed handwheel

_____c. Internal/external grinding selector knob

_____d. Cross-feed control lever

_____e. Machine start/stop push buttons

_____f. Switch operating slide throw-out lever

_____g. Disengagement knob

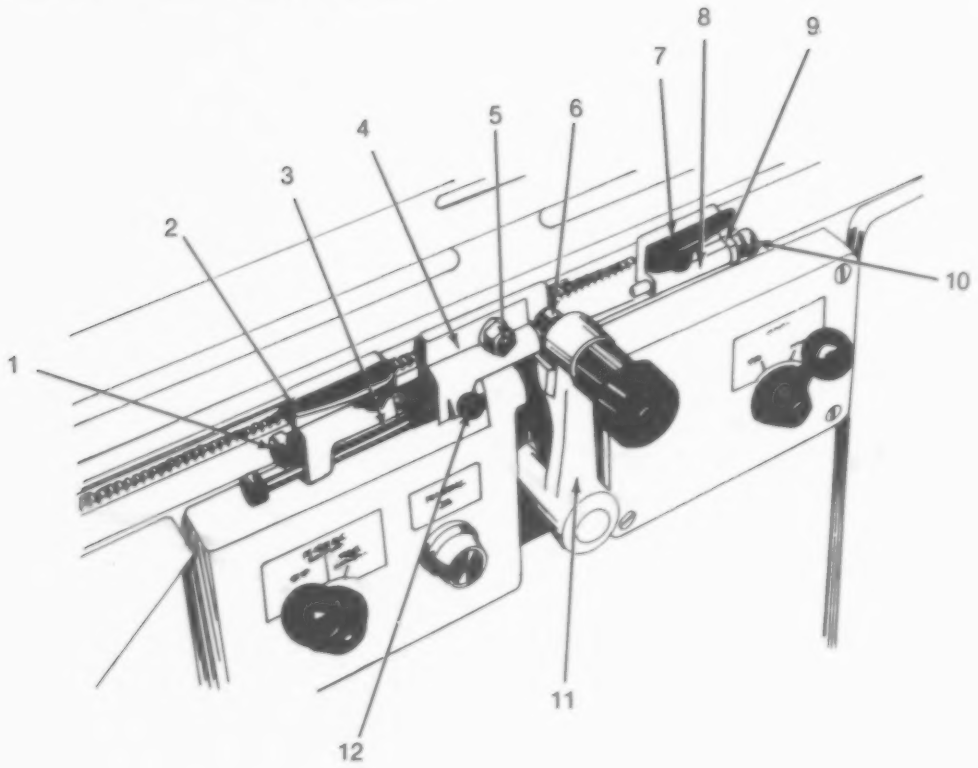
_____h. Cross-feed gear-shifting knob

_____i. Lever/handwheel selector switch

_____j. Headstock speed control knob

TEST

Controls on center front of machine



_____a. Table stop clamp screw

_____b. Check nut

_____c. Reversing lever plunger

_____d. Adjusting screw knob, left

_____e. Table dog clamp bolt

_____f. Table dog pawl lever, left

_____g. Table-reversing lever

_____h. Adjusting screw knob, right

_____i. Table dog pawl lever, right

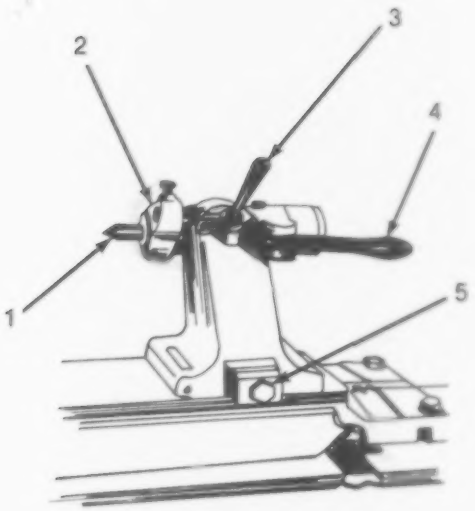
_____j. Table stop adjustment screw

_____k. Table dog, right

_____l. Table dog, left

TEST

Footstock



_____a. Operating lever

_____b. Footstock dust guard

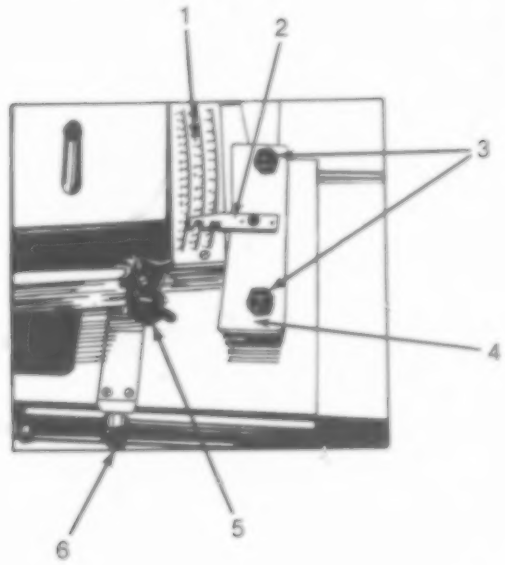
_____c. Footstock clamp and bolt

_____d. Spindle clamp handle

_____e. Center

TEST

Parts of the swivel table adjustment



_____a. Table clamp bolts

_____b. Table clamp

_____c. Index finger

_____d. Locking-pin knob

_____e. Swivel table scale

_____f. Adjusting nut

TEST

13. Name the three methods of applying coolants.

_____a. Small nozzle mixes coolant with air; mixture is blown onto wheel and workpiece; helps clean wheel and cool workpiece, and provides for an unobstructed view of wheel and workpiece

_____b. Coolant is stored in wheel flanges; holes drilled into wheel allow the wheel to absorb coolant to ensure that coolant gets to wheel/workpiece interface

_____c. Coolant is forced through piping to a nozzle that directs coolant onto wheel at point of contact, thus washing wheel and cooling workpiece; coolant drains back into system and is filtered before being recycled

14. Match grinding operation problems to their correct descriptions. Write the correct numbers in the blanks.

_____a. Breaking up of a grinding wheel as a result of turning faster than its maximum safe operating speed or from being improperly stored

_____b. Excessive vibration of grinding wheel

_____c. Areas on workpiece that have been allowed to heat excessively, causing them to expand and be ground off

_____d. Irregular marks left in surface of workpiece

_____e. Pattern produced on workpiece as a result of table or workpiece movement

_____f. Change in workpiece being ground caused by grinding heat; usually results in discoloration of surface

_____g. Unwanted pattern on workpiece resulting from slowing or stopping of grinding wheel due to excess pressure or friction

1. Burning
2. Chatter
3. Check marks
4. Explosion
5. Feed lines
6. Hollow spots
7. Scratches

15. Select from the following list possible causes of grinding operation problems. Write an "X" in the blank before each correct answer.

Chatter

_____a. Improperly or poorly dressed wheel

TEST

_____b. Wheel out of round

_____c. Wheel too soft

_____d. Wheel too coarse

_____e. Wheel out of balance

_____f. Misalignment of centers

_____g. Work loose on centers

_____h. Work centers not lubricated

_____i. Work mounted true on centers

_____j. Work centers damaged or not true

Scratches

_____a. Wheel too fine

_____b. Wheel too hard

_____c. Improperly or poorly dressed wheel

_____d. Oil spots on face of wheel

_____e. Ragged wheel edges

_____f. Dirty coolant

_____g. Dirt on wheel guard

_____h. Bond allowing abrasives to be pulled out

_____i. Glazed or loaded wheel

_____j. Wrong type of coolant

Spirals

_____a. Worn spot in table

_____b. Misalignment of centers

_____c. Ragged wheel edges

_____d. Improperly or poorly dressed wheel

_____e. Centers tight on workpiece

_____f. Vibrations of drive belt

_____g. Table travel too slow

_____h. Wrong type of coolant

_____i. Internal machine vibrations

_____j. Wheel too hard

Check marks

_____a. Coolant not properly applied

_____b. Too much coolant

_____c. Grit too fine

_____d. Wheel too soft

_____e. No coolant (dry grinding)

_____f. Improperly or poorly dressed wheel

_____g. Cutting pressure too great

_____h. Improper travel or work speed

_____i. Glazed or loaded wheel

_____j. Workpiece not properly secured

Short and long wave marks

_____a. Wheel out of round

_____b. Vibrations of drive belt

_____c. Wheel speed too fast

_____d. Internal machine vibrations

_____e. Not enough cutting pressure

_____f. Wheel out of balance

_____g. Insufficient coolant

TEST

_____h. Work centers not lubricated

_____i. Oil spots on face of wheel

_____j. Incorrect arbor size

Feed lines

_____a. Wheel too hard

_____b. Improperly or poorly dressed wheel

_____c. Improper travel or work speed

_____d. Wheel out of round

_____e. Worn spot in table ways

_____f. Misalignment of centers

_____g. Coolant not properly applied

_____h. Wheel too fine

_____i. Ragged wheel edge

_____j. Oil spots on face of wheel

Burnt or discolored finish

_____a. Cutting pressure too great

_____b. No coolant (dry grinding)

_____c. Wrong type of coolant

_____d. Misalignment of centers

_____e. Wheel too hard

_____f. Improperly or poorly dressed wheel

_____g. Wheel too coarse

_____h. Coolant not properly applied

_____i. Glazed or loaded wheel

_____j. Table travel too slow

TEST

16. State rules for grinding machine safety. Explain how each of the following words or phrases applies to grinding machine safety.

a. Eyes — _____

_____

_____

b. Guards — _____

_____

_____

c. Hands — _____

_____

_____

d. Ring test — _____

_____

_____

e. Handling — _____

_____

_____

TEST

f. Storing — _____

_____

_____

g. Force — _____

_____

_____

h. Operating speed — _____

_____

_____

i. Mounting flanges — _____

_____

_____

j. Mounting blotters — _____

_____

_____

k. Mounting nut — _____

_____

_____

l. Starting — _____

_____

_____

m. Grinding — _____

_____

_____

TEST

n. Wheel selection — _____

_____

_____

o. Wet grinding — _____

_____

_____

p. Work — _____

_____

_____

q. Trip dogs — _____

_____

_____

r. Dressing — _____

_____

_____

s. Centers — _____

_____

_____

(NOTE: Test questions 17 and 18 list the assignment and job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

17. Interpret grinding wheel markings.

18. Demonstrate the ability to

    a. Operate surface grinder controls properly.

    b. Operate cylindrical grinder controls properly for manual feeds.

    c. Operate cylindrical grinder controls properly for power feeds.

    d. Balance a grinding wheel.

    e. Mount a chuck to headstock.

GRINDING MACHINES
UNIT I

ANSWERS TO TEST

1.	a.	5	h.	1
	b.	7	i.	14
	c.	4	j.	9
	d.	10	k.	13
	e.	8	l.	6
	f.	3	m.	11
	g.	12	n.	2
2.	a.	4	c.	3
	b.	2	d.	1
3.	a.	Face	d.	Periphery
	b.	Arbor hole	e.	Bushing
	c.	Wall		
4.	a.	3	d.	4
	b.	5	e.	2
	c.	1	f.	6
5.	a.	2	d.	1
	b.	4	e.	3
	c.	5		

6. a. To make the wheel concentric with spindle of grinding machine
   b. To eliminate chatter marks
   c. To eliminate vibration

ANSWERS TO TEST

d. To prevent wheel breakage

e. To prevent excessive bearing failure and damage to spindle

7. a. Universal and tool grinder

b. Internal/external grinder

c. Surface grinder

d. Universal grinder

8.

a.	Wheel guard	j.	Cross-feed directional lever
b.	Dust deflector	k.	Fine-feed locknut
c.	Table-reversing lever	l.	Elevating handwheel
d.	Table handwheel	m.	Fine-feed adjustment knob
e.	Dial locknut	n.	Table dog
f.	Cross-feed handwheel	o.	Table
g.	Oil level sight glass	p.	Upright
h.	Wheel truing and rapid positioning lever	q.	Spindle
i.	Cross-feed regulating screw		

9.

a.	12	g.	3	m.	10
b.	1	h.	17	n.	9
c.	4	i.	8	o.	14
d.	13	j.	11	p.	16
e.	15	k.	5	q.	7
f.	6	l.	2		

ANSWERS TO TEST

10.

a.	Headstock		g.	Cross-feed handwheel
b.	Swivel table		h.	Machine start/stop push buttons
c.	Sliding table		i.	Electrical control compartment
d.	Table dog		j.	Footstock
e.	Table handwheel		k.	Internal spindle
f.	Table-reversing lever		l.	External spindle

11.

a.	5	e.	10	i.	3
b.	6	f.	4	j.	8
c.	12	g.	2	k.	9
d.	7	h.	1	l.	11

12. **Headstock**

a.	6	e.	2
b.	4	f.	8
c.	1	g.	3
d.	7	h.	5

Upright

a.	16	e.	3	i.	7	m.	1
b.	13	f.	14	j.	11	n.	12
c.	2	g.	9	k.	15	o.	8
d.	6	h.	4	l.	10	p.	5

ANSWERS TO TEST

Controls on left front of machine

a.	8	f.	4
b.	10	g.	5
c.	2	h.	7
d.	6	i.	3
e.	1	j.	9

Controls on right front of machine

a.	3	f.	1
b.	5	g.	4
c.	10	h.	6
d.	2	i.	7
e.	8	j.	9

Controls on center front of machine

a.	12	g.	11
b.	9	h.	10
c.	6	i.	7
d.	1	j.	3
e.	5	k.	8
f.	2	l.	4

Footstock

a.	4	d.	3
b.	2	e.	1
c.	5		

ANSWERS TO TEST

Parts of swivel table adjustment

a.	3	d.	5
b.	4	e.	1
c.	2	f.	6

13. a. Mist or spray
    b. Through-the-wheel
    c. Flood

14.

a.	4	e.	5
b.	2	f.	1
c.	6	g.	3
d.	7		

15. **Chatter**

a, b, e, f, g, h, j

Scratches

c, d, e, f, h, i, j

Spirals

b, d, f, i

Check marks

a, e, g, h, i

Short and long wave marks

a, b, d, f, h, i

Feed lines

b, c, e, f, g, i

Burnt or discolored finish

a, b, c, e, f, h, i

ANSWERS TO TEST

16. a. Eyes — Wear approved safety glasses or approved eye protection when performing any type of grinding operation

    b. Guards — Never operate grinding machines with safety guards removed

    c. Hands — Keep hands away from revolving wheel and workpiece during grinding

    d. Ring test — Ring test all grinding wheels before mounting

    e. Handling — Handle all grinding wheels carefully; use rubber hose over hoist cables when handling large wheels

    f. Storing — Store all straight wheels upright; store cup, dish, and saucer wheels flat with cardboard between layers

    g. Force — Never force a grinding wheel on a machine spindle

    h. Operating speed — Never exceed manufacturer's maximum allowable operating speed of wheel

    i. Mounting flanges — Use mounting flanges of correct diameter and those in good condition so that they apply even pressure to sides of wheel

    j. Mounting blotters — Use paper blotters on both sides of wheel so that pressure from flanges is evenly applied to sides of wheel

    k. Mounting nut — Tighten mounting nut only tight enough to keep wheel from slipping; excessive tightening may crack wheel

    l. Starting — Bring wheels that are at least 12 inches in diameter up to operating speed slowly by jogging start/stop switches; allow wheel to run one minute before using

    m. Grinding — Do not force work into wheel

    n. Wheel selection — Use correct wheel for material and type of grinding being done

    o. Wet grinding — Turn off coolant and allow wheel to run several minutes to remove excess coolant

    p. Work — Mount and secure workpiece properly; adjust workpiece between centers carefully

    q. Trip dogs — Set trip dogs with care to avoid contact between wheel and machine

    r. Dressing — Tilt fixed dressing tools 3 degrees in direction of rotation and slightly left of or below center

    s. Centers — Lubricate center holes of workpiece with a compound other than lead to prevent damage to centers

17. Evaluated to the satisfaction of the instructor

18. Performance skills evaluated to the satisfaction of the instructor

SURFACE GRINDING
UNIT II

UNIT OBJECTIVE

After completing this unit, the student should be able to set up and operate a surface grinder, select proper composition and shape of grinding wheels, dress grinding wheels, perform flat and angular grinding operations, and be able to use various work-holding and mounting devices. The student will show this knowledge by completing assignment sheets, job sheets, and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with surface grinding to their correct definitions.
2. Identify surface grinding operations.
3. Identify types of grinding wheels used for specific surface grinding operations.
4. Select proper grinding-wheel composition for different materials.
5. Match types of grinding-wheel dressers to their correct functions/descriptions.
6. Identify work-holding devices.
7. Match the parts of a radius and tangent dresser to their correct uses.
8. Select from a list probable causes of surface grinding problems.
9. State safety rules that apply to magnetic chuck work.
10. Demonstrate the ability to
    a. Remove and replace a grinding wheel.
    b. Dress a wheel flat.
    c. Grind a workpiece flat and parallel.
    d. Grind a workpiece square.
    e. Grind an angular surface.
    f. Grind an angular surface using connetic V-block.
    g. Grind a vertical surface.

OBJECTIVE SHEET

h. Grind a workpiece to dimension.

i. Dress a grinding wheel to a 90-degree included angle.

j. Dress a grinding wheel having a 1/8-inch radius and 30- and 40-degree angles tangent to radius.

SURFACE GRINDING
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities

A. Obtain materials necessary to supplement unit.

B. Make transparency.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information, assignment, and job sheets.

F. Discuss information and assignment sheets.

(NOTE: Assignment Sheets #1 through #5 can be used as a review of the job sheets or may be used to prepare students for the job sheets.)

G. Demonstrate and discuss procedures outlined in job sheets, and modify job sheets to fit your equipment.

H. Demonstrate safety required for magnetic chuck.

I. Give test.

J. Reteach and retest if necessary.

II. Instructional materials

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Transparency Master #1 — Parts of a Radius and Tangent Dresser

E. Assignment sheets

1. Assignment Sheet #1 — Identify Correct Work-Holding Devices for Surface Grinding Operations

2. Assignment Sheet #2 — Plan Procedures to Grind Parallels

3. Assignment Sheet #3 — Plan Procedures to Grind a Set of Setup Blocks

4. Assignment Sheet #4 — Plan Procedures to Grind a Step Angle Plate

5. Assignment Sheet #5 — Plan Procedures to Grind a V-Block

SUGGESTED ACTIVITIES

F. Answers to assignment sheets

G. Job sheets

1. Job Sheet #1 — Remove and Replace a Grinding Wheel
2. Job Sheet #2 — Dress a Wheel Flat
3. Job Sheet #3 — Grind a Workpiece Flat and Parallel
4. Job Sheet #4 — Grind a Workpiece Square
5. Job Sheet #5 — Grind an Angular Surface
6. Job Sheet #6 — Grind an Angular Surface Using Connetic V-Block
7. Job Sheet #7 — Grind a Vertical Surface
8. Job Sheet #8 — Grind a Workpiece to Dimension
9. Job Sheet #9 — Dress a Grinding Wheel to a 90-Degree Included Angle
10. Job Sheet #10 — Dress a Grinding Wheel Having a 1/8-Inch Radius and 30- and 40-Degree Angles Tangent to Radius

H. Test

I. Answers to test

III. Unit references

A. Kibbe, Richard R., et al. *Machine Tools and Machining Practices, Volume II.* New York: John Wiley and Sons, Inc., 1977

B. Krar, S.F., and J.W. Oswald. *Grinding Technology.* Albany, New York: Delmar Publishers, 1974.

C. Krar, S.F., J.W. Oswald, and J.E. St. Amand. *Technology of Machine Tools.* Toronto: McGraw-Hill Company of Canada Limited, 1969.

D. *Operator's Manual #23-99990-11: C18 Micromaster Surface Grinding Machines.* Brown and Sharpe Manufacturing Company, n.d.

SURFACE GRINDING
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Traverse — Horizontal movement of the table right and left

B. Reciprocating — Moving alternately back and forth

C. Across — Movement of grinding wheel from back to front during grinding operation

D. Surface finish — Appearance or degree of smoothness of workpiece

E. Fishtails — Random scratches on workpiece surface

F. Flat — Surface that is straight and free of warps or bows

G. Stress — Internal strain in workpiece produced by manufacturing, machining, or heat-treating

H. Energize — To apply power to a magnetic device

I. Dress — To shape grinding wheel flat, or to a specific form, and to expose new, sharp cutting particles

J. Concave — Inward-curving surface (Figure 1)

EXAMPLE:

FIGURE 1

K. Convex — Outward-curving surface (Figure 2)

EXAMPLE:

FIGURE 2

L. Grindability — Degree of difficulty involved in grinding a material

M. Stone the chuck — To remove burrs by rubbing surface of magnetic chuck with hard oilstone

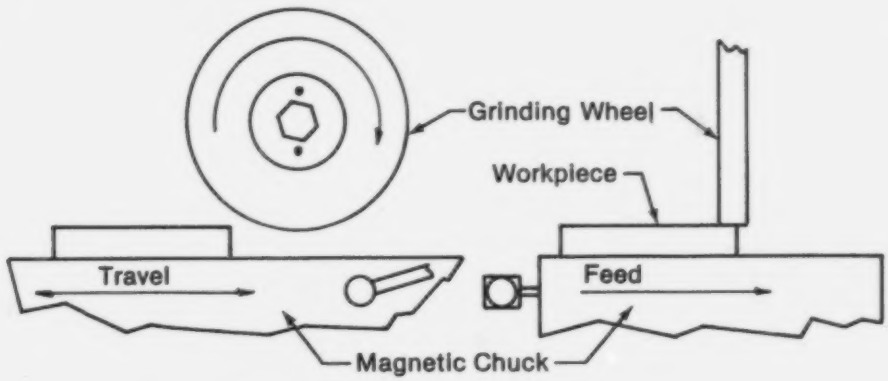
INFORMATION SHEET

N. Scale — Carbon and other impurities on the surface of steel that has been heat-treated or hot-rolled

II. Surface grinding operations (Figures 3-9; Assignment Sheets #1-#5)

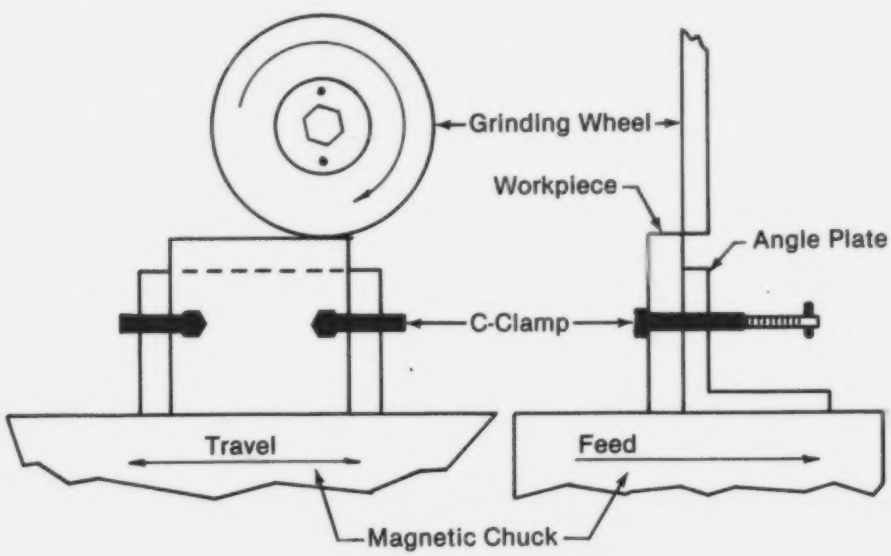
A. Grinding flat surfaces

FIGURE 3



B. Grinding edges

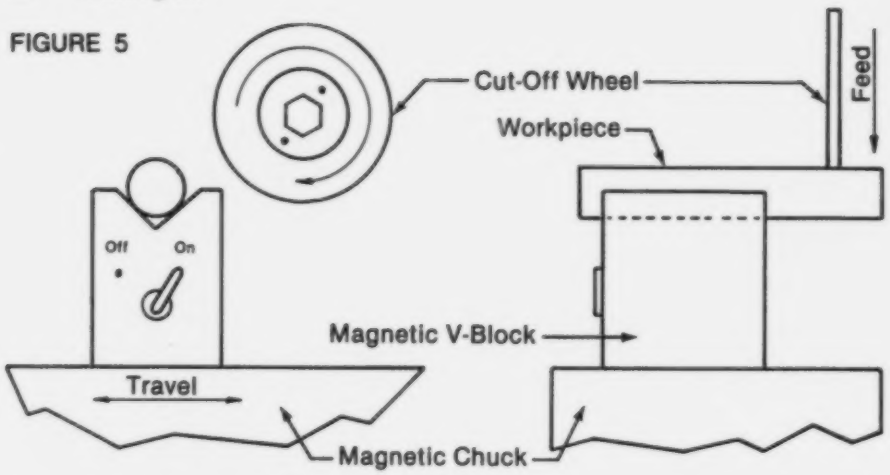
FIGURE 4



INFORMATION SHEET

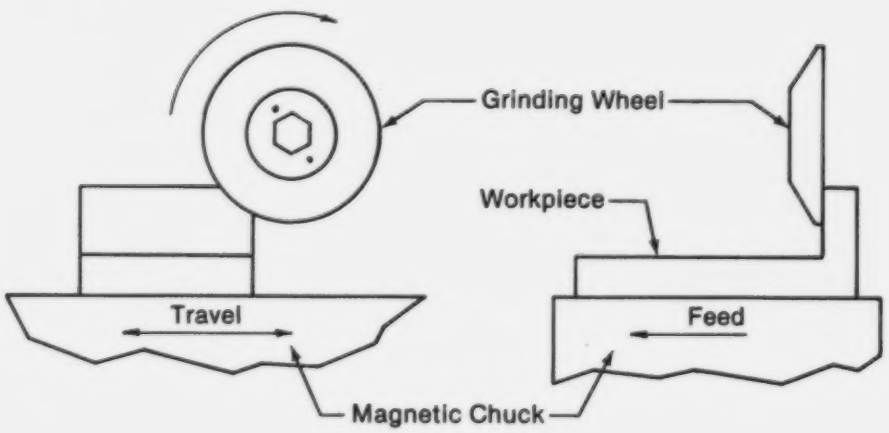
C. Cutting off

FIGURE 5



D. Grinding vertical surfaces

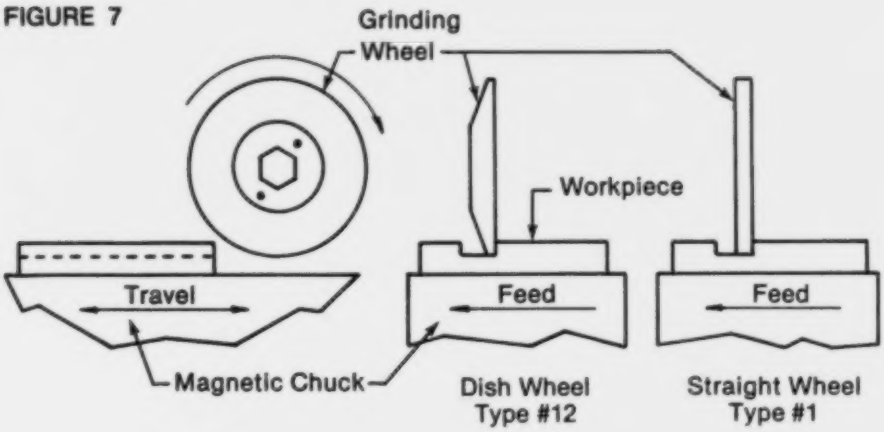
FIGURE 6



INFORMATION SHEET

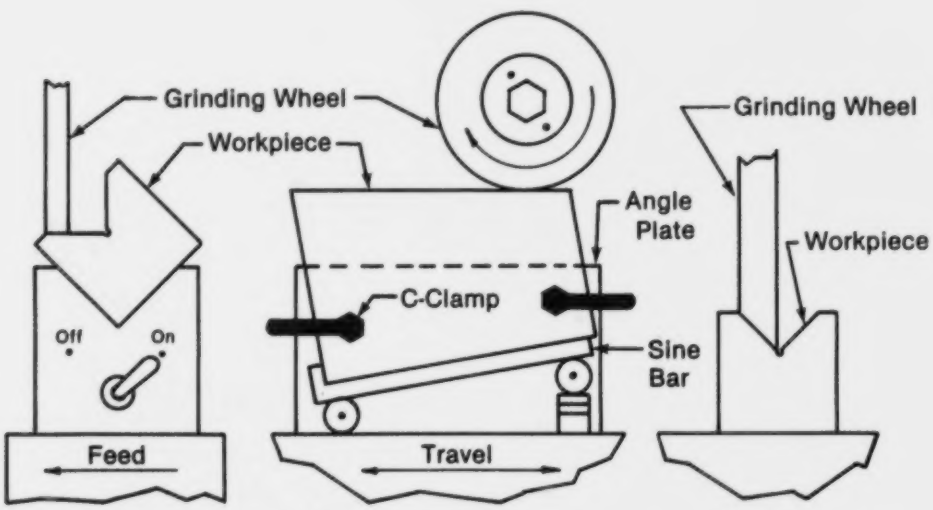
E. Grinding grooves or slots

FIGURE 7



F. Grinding angular surfaces

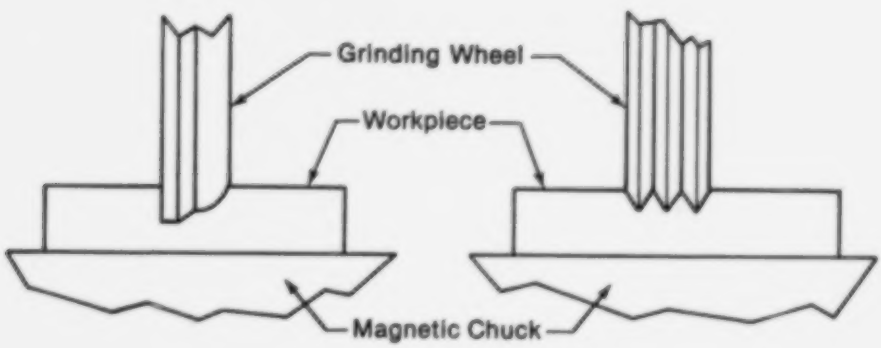
FIGURE 8



INFORMATION SHEET

G. Form or profile grinding

FIGURE 9



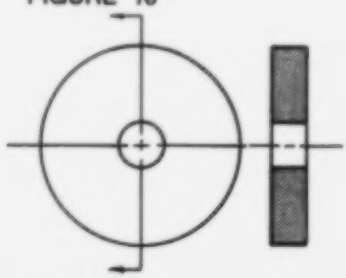
III. Types of grinding wheels used for specific surface grinding operations (Figures 10-12; Assignment Sheet #2)

A. Type #1 (straight wheel)

1. Grinding flat surfaces
2. Grinding edges
3. Cutting off
4. Grinding grooves or slots
5. Grinding angular surfaces
6. Form grinding

EXAMPLE:

FIGURE 10

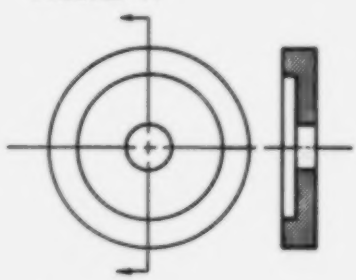


B. Type #5 (recessed one side)

1. Grinding flat surfaces
2. Grinding edges
3. Grinding angular surfaces
4. Form grinding

EXAMPLE:

FIGURE 11



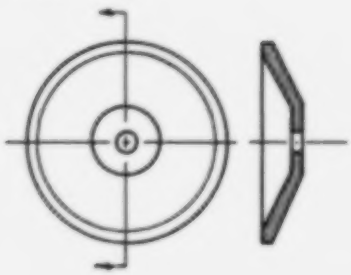
INFORMATION SHEET

C. Type #12 (dish)

1. Grinding flat surfaces
2. Grinding vertical surfaces
3. Grinding grooves or slots

EXAMPLE:

FIGURE 12



IV. Grinding-wheel composition for different materials (Assignment Sheet #2)

(NOTE: Due to the many factors involved in wheel selection, only abrasive and bond will be discussed.)

A. High speed steel — Aluminum oxide with vitrified bond, or cubic boron nitride with resinoid bond

EXAMPLES: 32A46-H8VBE, AA46-J8V40 } Aluminum oxide
CB100-TBB1/16 Cubic boron nitride

B. Hardened steel — Aluminum oxide with vitrified bond

EXAMPLES: 32A46-H8VBE
DA46-I8V20
PA36-J8V40

C. Soft steel — Aluminum oxide with vitrified bond

EXAMPLES: 23A46-J8VBE
PA46-J8V40

D. Cast iron (soft), bronze, and aluminum — Silicon carbide with vitrified bond

EXAMPLE: 37C30KVK

E. Carbide — Silicon carbide with vitrified bond, or diamond with metal bond

EXAMPLES: 39C60-I8VK
MD150-N50V5 1/16
M120-N50M 1/16

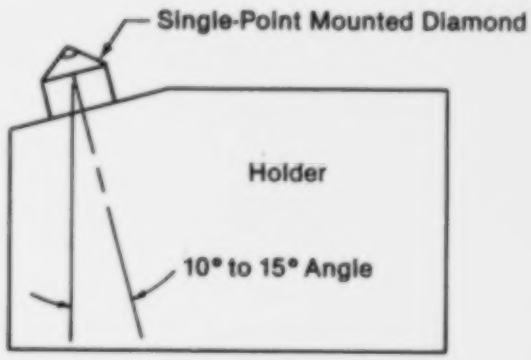
INFORMATION SHEET

V. Grinding-wheel dressers

A. Single-point mounted diamond held in holder — Holder is mounted directly to magnetic chuck; dresses periphery of grinding wheel flat (Figure 13)

EXAMPLE:

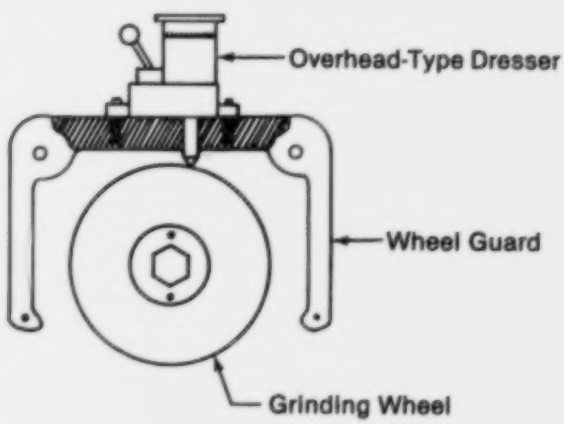
FIGURE 13



B. Single-point mounted diamond held in overhead-type dresser — Permanently mounted to wheel guard; dresses periphery of grinding wheel flat (Figure 14)

EXAMPLE:

FIGURE 14



INFORMATION SHEET

C. Dressing stick — Hand-held dresser used to remove ragged edges from grinding wheel; also used for rough forming or shaping (Figure 15)

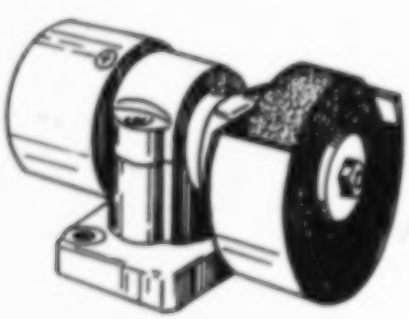
EXAMPLE:

FIGURE 15

D. Brake-controlled dressing and truing device — Mounted dresser used to dress and true grinding wheel; can be used to true diamond wheels when used with proper dressing stone (Figure 16)

EXAMPLE:

FIGURE 16

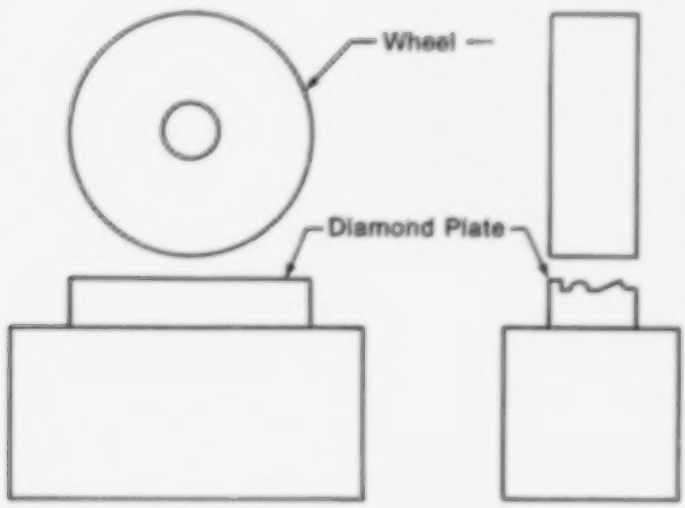


INFORMATION SHEET

E. Diamond-plate dressing block — Primarily used for form or contour dressing; shape of plate dresses grinding wheel; dressers of this type are usually mounted so that dressing can occur during grinding operation (Figure 17)

EXAMPLE:

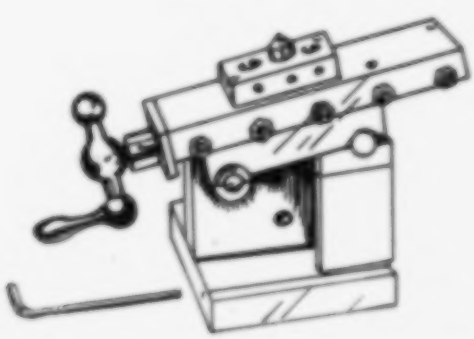
FIGURE 17



F. Sine dresser (angle dresser) — Mounts to magnetic chuck; is adjusted to desired angle; dressing of wheel may be done mechanically or by hand using a diamond mounted in holder (Figure 18)

EXAMPLE:

FIGURE 18

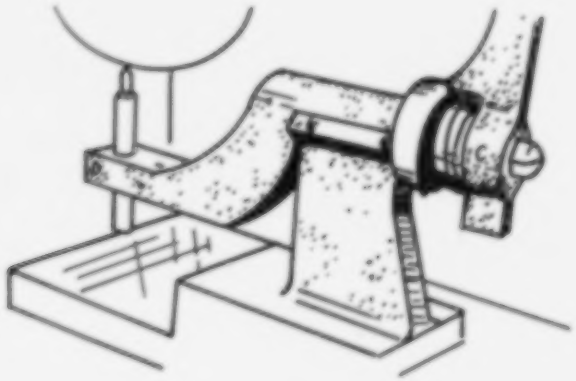


INFORMATION SHEET

G. Radius dresser — Form dresses wheel by using a diamond to generate a set radius for a concave or convex surface (Figure 19)

EXAMPLE:

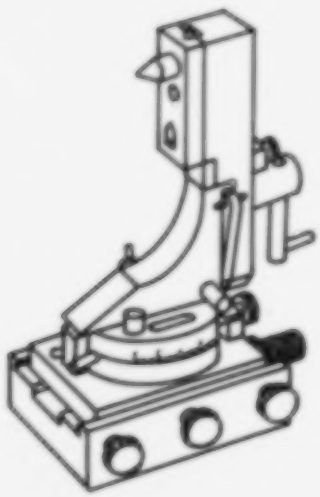
FIGURE 19



H. Radius and tangent dresser — Form dresses wheel by using a diamond to generate angles, radii, or a combination of an angle and radius (Figure 20)

EXAMPLE:

FIGURE 20

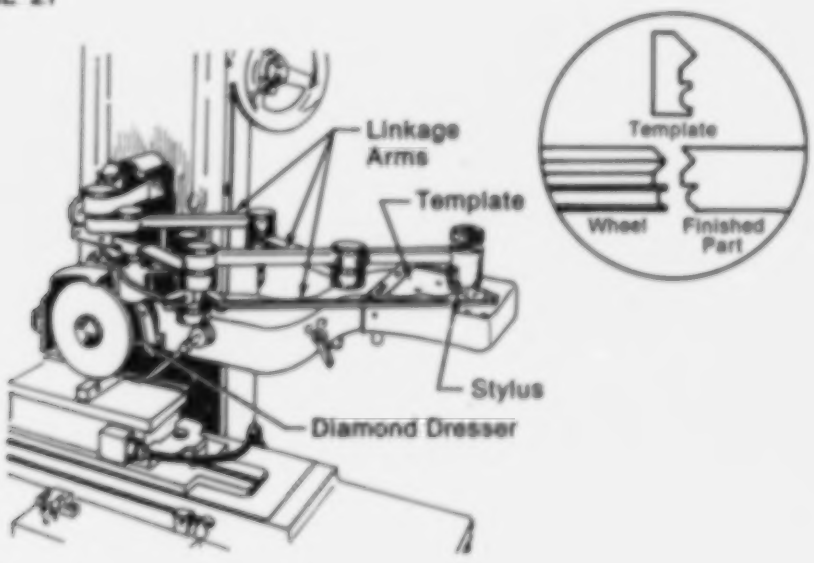


INFORMATION SHEET

I. Pantograph or template-type dresser — Form dresses wheel by using a mechanical finger that follows a template and generates shape of template (Figure 21)

EXAMPLE:

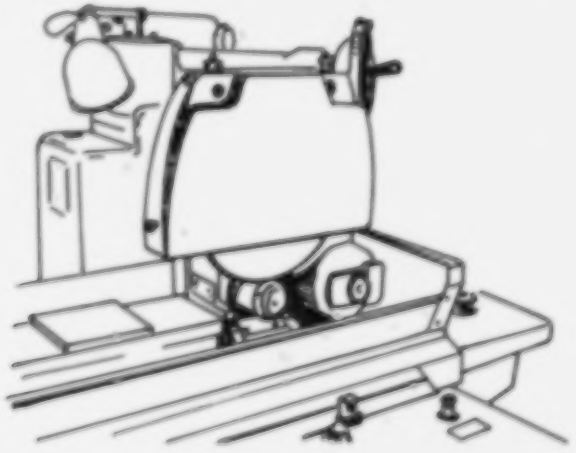
FIGURE 21



J. Roll dresser — Mounted to chuck or table; used to rough dress grinding wheels concentric to spindle prior to flat dressing (Figure 22)

EXAMPLE:

FIGURE 22



INFORMATION SHEET

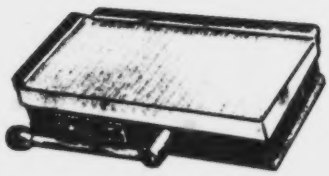
VI. Work-holding devices (Figures 23-38; Assignment Sheets #1 and #2)

A. Magnetic chucks

FIGURE 23

Electromagnetic

FIGURE 24

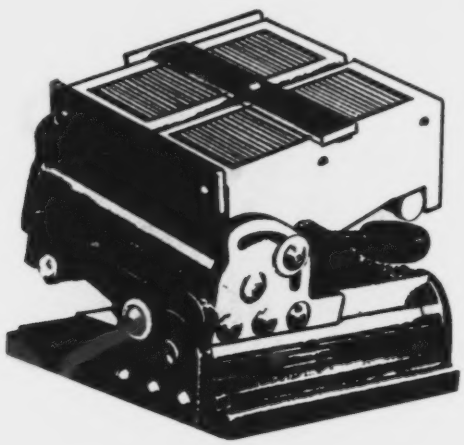


Permanent Magnetic

B. Compound sine chuck

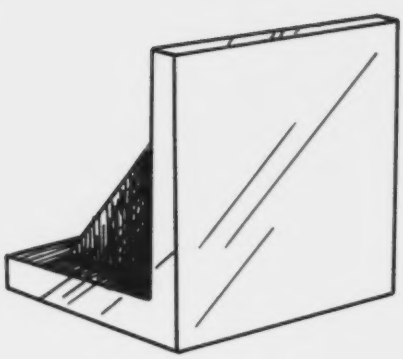
(NOTE: The compound sine chuck is available in both electromagnetic and permanent magnetic types.)

FIGURE 25



C. Angle plate

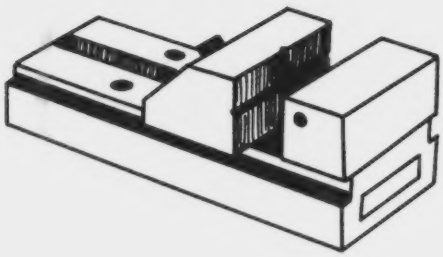
FIGURE 26



INFORMATION SHEET

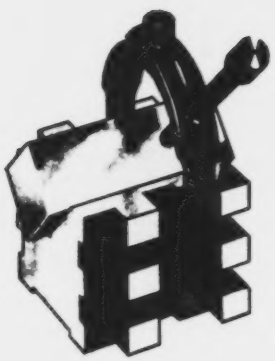
D. Vise (precision)

FIGURE 27



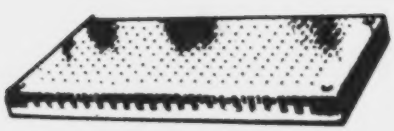
E. V-block and clamp

FIGURE 28



F. Vacuum chuck

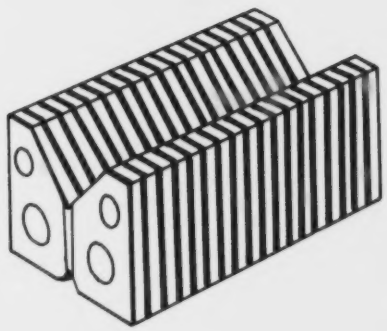
FIGURE 29



INFORMATION SHEET

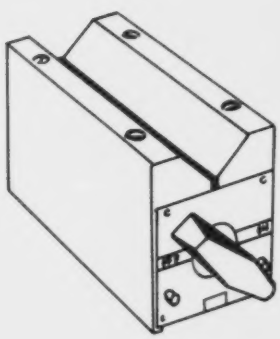
G. Connetic V-block

FIGURE 30



H. Magnetic V-block

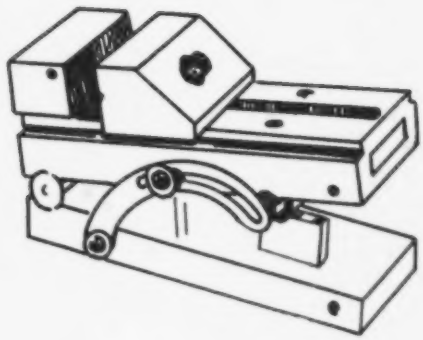
FIGURE 31



INFORMATION SHEET

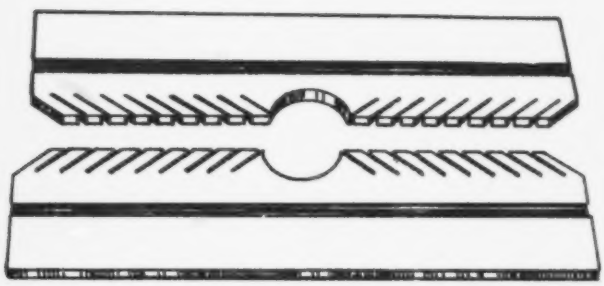
I. Sine vise

FIGURE 32



J. Magna-vise clamps

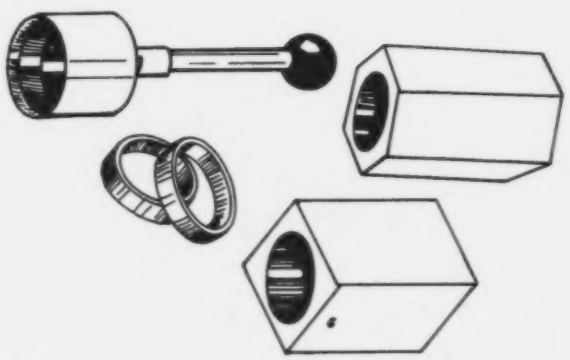
FIGURE 33



INFORMATION SHEET

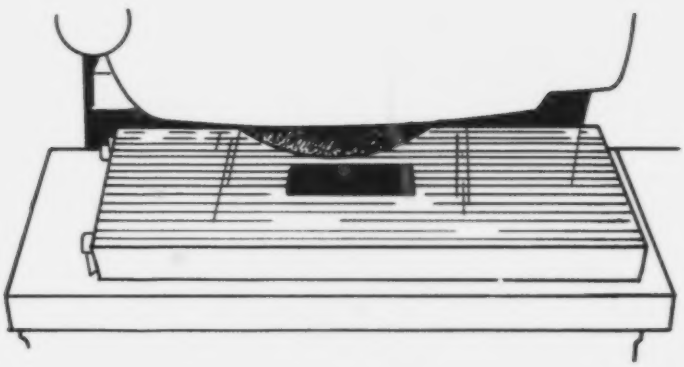
K. Collet block chucks

FIGURE 34



L. Adapter plate

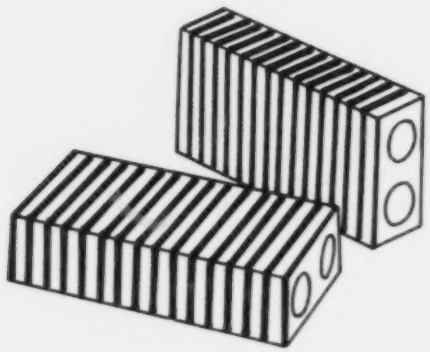
FIGURE 35



INFORMATION SHEET

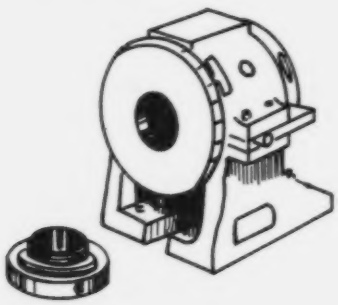
M. Connetic parallels

FIGURE 36



N. Indexing collet fixture

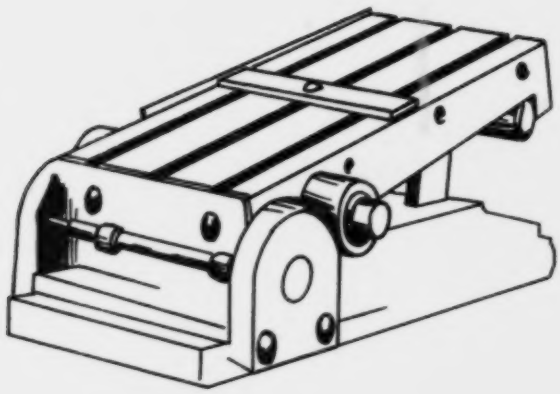
FIGURE 37



INFORMATION SHEET

O. Adjustable angle plate

FIGURE 38



VII. Parts of a radius and tangent dresser and their uses (Transparency #1)

A. Diamond — Cuts wheel to shape

B. Micrometer plate — Calibrates diamond to swivel base

C. Traverse lock — Prevents movement of angle traverse control handle

D. Angle traverse control handle — Moves diamond in a straight line at angle desired

E. Swivel-ring locking screw — Allows swivel ring to be set to generate a radius up to 180 degrees

F. Micrometer base lead-screw knob — Moves swivel-base slide with micrometer accuracy; calibrated in 0.001-inch increments

G. Vernier plate — Indicates amount of movement of swivel ring

H. Gib tension screws — Lock swivel-base slide in base

I. Base — Supports swivel-base slide and upright

J. Swivel-base slide — Supports swivel base; allows horizontal movement of swivel base

K. Swivel base — Used with swivel ring to set amount of radius

L. Swivel ring — Rotates on swivel base to set amount of radius

M. Fixed stop — Stops rotation of upright by making contact with swivel-ring stop pins

INFORMATION SHEET

N. Swivel-ring stop pins — Stop swivel-base and ring rotation at setting of fixed stop

O. Upright — Supports diamond and micrometer plate

P. Slide lock — Locks slide in place at setting of micrometer pins

Q. Micrometer pins — Set radius limits

VIII. Surface grinding problems and probable causes

A. Burning or checking

1. Wheel not dressed or improperly dressed
2. Wheel too fine
3. Wheel too hard
4. Coolant applied improperly
5. Excessive feed
6. Excessive depth of cut

B. Chatter

1. Wheel too hard
2. Wheel too soft
3. Wheel out of balance
4. Wheel out of round
5. Internal machine vibrations
6. External machine vibrations
7. Spindle bearings bad

C. Scratches

1. Coolant dirty
2. Chuck dirty or burred
3. Loose dirt under guard

4. Wheel too soft
5. Wheel too coarse
6. Wheel not dressed or improperly dressed
7. Workpiece not held securely

D. Concave or convex areas on workpiece

1. Wheel too hard
2. Wheel not dressed or improperly dressed
3. Chuck dirty or burred
4. Coolant applied improperly
5. Table feed too slow
6. Heat-treatment stress
7. Workpiece too thin

IX. Safety rules that apply to magnetic chuck work

A. Cleaning — Clean top surface of chuck before placing anything on chuck

B. Deburring — Rub top surface of chuck with a hard, fine oilstone to remove nicks and burrs

C. Workpiece — Carefully place workpiece on chuck to avoid nicking, burring, or scratching the chucking surface; never chuck workpiece that has burrs

D. Paper — Use thin grinding paper between workpiece and chuck surface

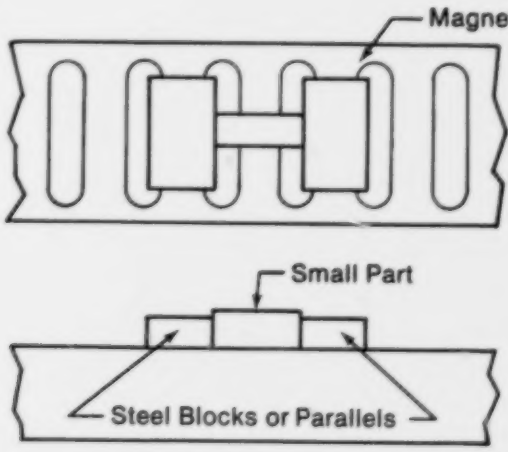
E. Magnetized strips — If possible, touch three magnetized strips to workpiece for sufficient holding power

INFORMATION SHEET

F. Small parts — Block small parts with steel bars or parallels to prevent work from slipping (Figure 39)

EXAMPLE:

FIGURE 39



G. Jewelry — Never wear jewelry while using magnetic chuck

H. Setup — Before grinding always check setup to make sure that workpiece is firmly held

I. Eyes — Wear approved eye protection when operating grinder

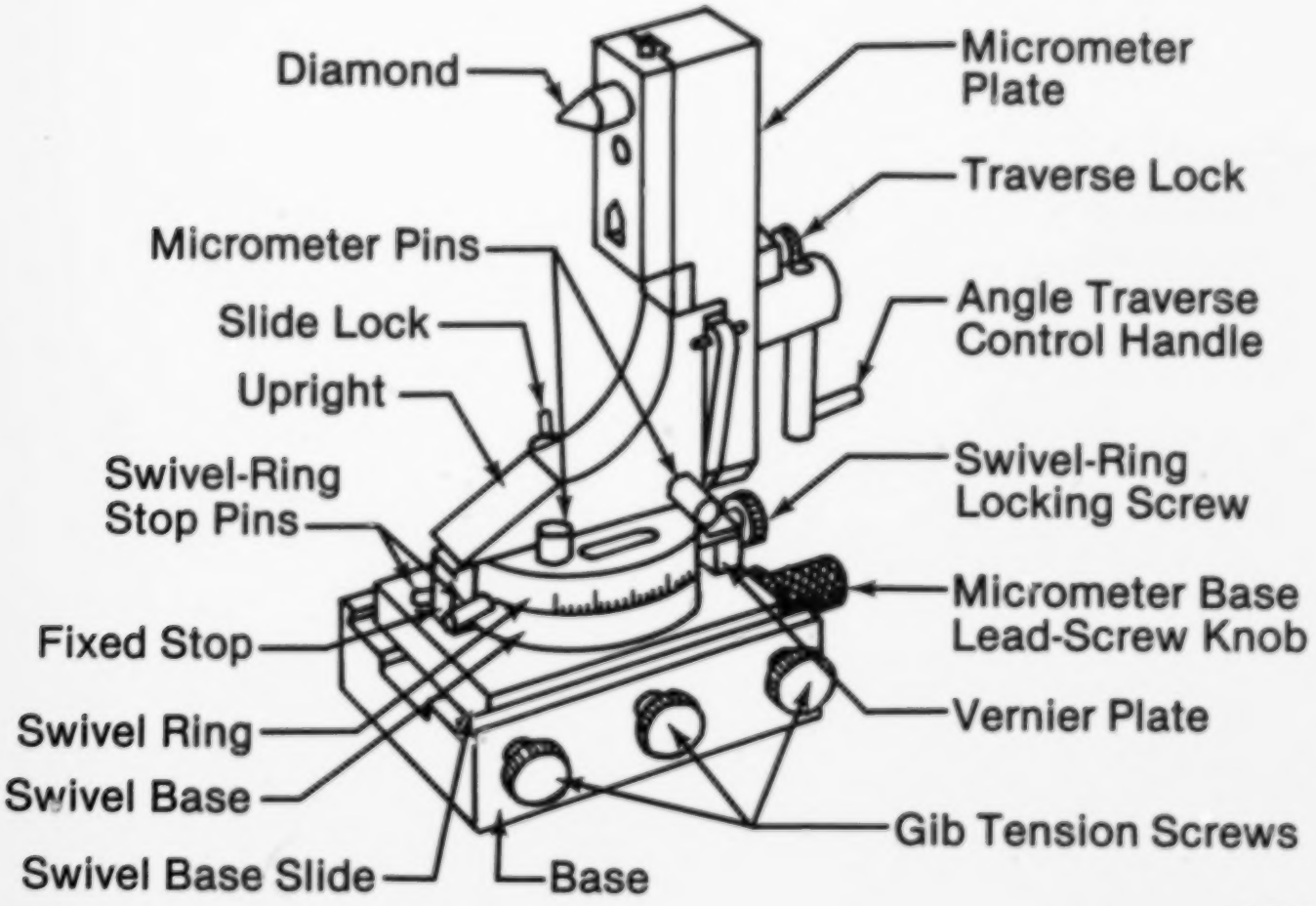
J. Connetic V-blocks and parallels — Position laminated setup tools with laminations parallel to inner poles of magnetic chuck so that holding power is transferred to workpiece

K. Magna-vise clamps — Check workpiece to ensure that it is held securely

L. Side and end plates — Remove before resurfacing magnetic chuck

M. Resurfacing — Always regrind chuck surface with chuck energized, using cuts of no more than 0.001 inch per pass

Parts of a Radius and Tangent Dresser



SURFACE GRINDING
UNIT II

ASSIGNMENT SHEET #1 — IDENTIFY CORRECT WORK-HOLDING DEVICES FOR SURFACE GRINDING OPERATIONS

NAME _____ SCORE _____

The ability to determine how to hold a workpiece for grinding is a skill that you must learn if you are to complete a grinding job accurately.

Identify the work-holding device or devices you would use when performing the grinding operations described on the following pages. Write the names of the devices in the blanks provided.

(NOTE: If more than one work-holding device can be used, list all possible choices.)

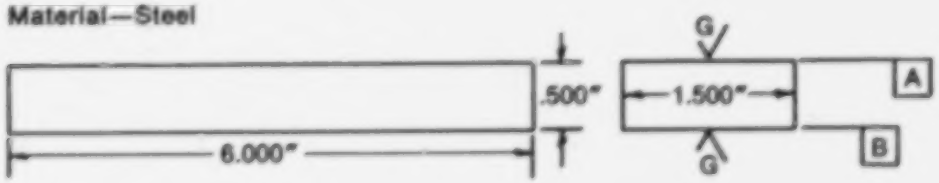
ASSIGNMENT SHEET #1

Magnetic chuck
Connetic V-block
Connetic parallels
Magnetic V-block
V-block and clamp
Angle plate, clamp, and adjustable parallel

Magnetic sine chuck
Adjustable angle vise
Angle plate, clamps, and sine bar
Magna-vise clamps

A. Grinding surfaces A and B parallel to each other and flat within ± .0001 inch

Material—Steel



1. _____

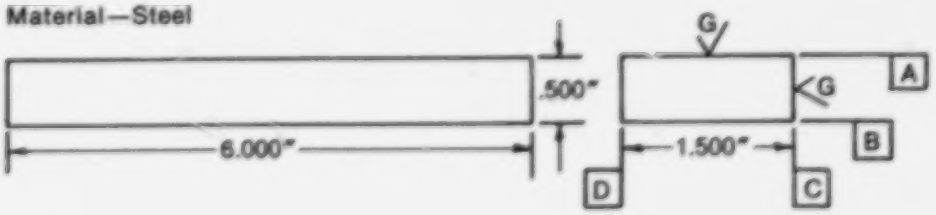
2. _____

3. _____

B. Grinding surface C perpendicular to surfaces A and B and parallel to surface D

(NOTE: Surfaces A and B have been ground parallel. Surfaces C and D have not been ground.)

Material—Steel



1. _____

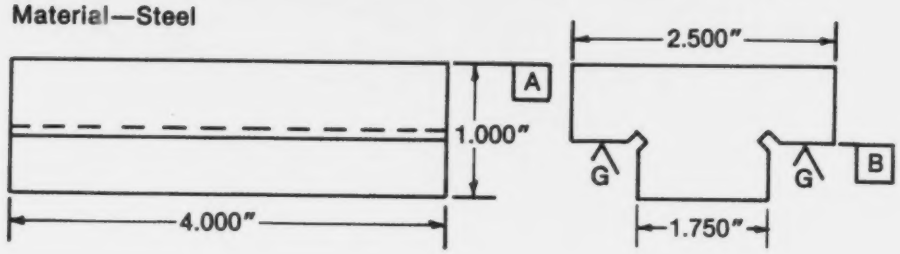
2. _____

ASSIGNMENT SHEET #1

Magnetic chuck
Connetic V-block
Connetic parallels
Magnetic V-block
V-block and clamp
Angle plate, clamp, and adjustable parallel
Magnetic sine chuck
Adjustable angle vise
Angle plate, clamps, and sine bar
Magna-vise clamps

C. Grinding surface A flat and parallel to surface B, which has been ground

Material—Steel

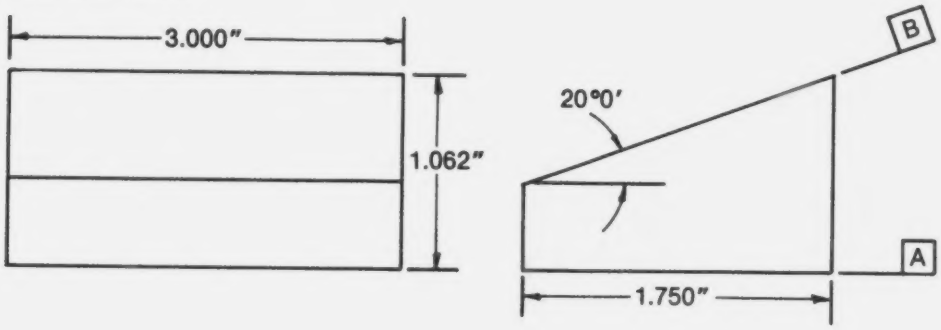


1. _____
2. _____
3. _____

D. Grinding angular surface B at a 20-degree angle to surface A

(NOTE: Surface A has been ground.)

Material—Steel

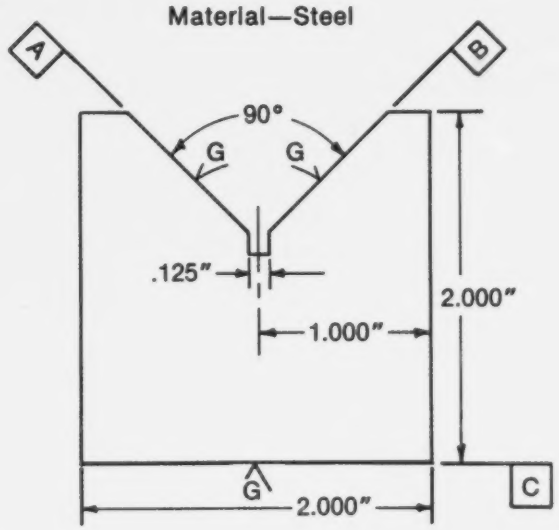


1. _____
2. _____
3. _____

ASSIGNMENT SHEET #1

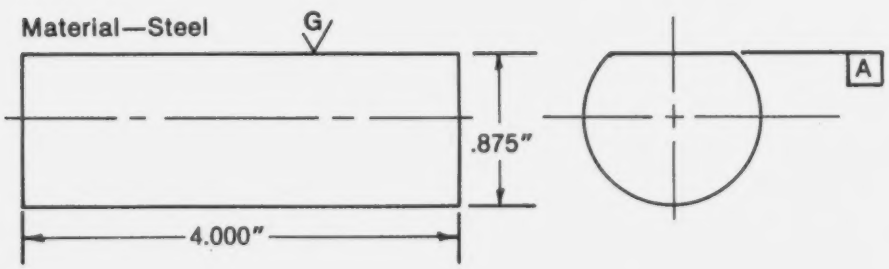
Magnetic chuck
Connetic V-block
Connetic parallels
Magnetic V-block
V-block and clamp
Angle plate, clamp, and adjustable parallel
Magnetic sine chuck
Adjustable angle vise
Angle plate, clamps, and sine bar
Magna-vise clamps

E. Grinding surfaces A and B 90 degrees to each other and 45 degrees to surface C, which has been ground



1. _____
2. _____
3. _____

F. Grinding the flat surface A on a round steel shaft 4 inches long



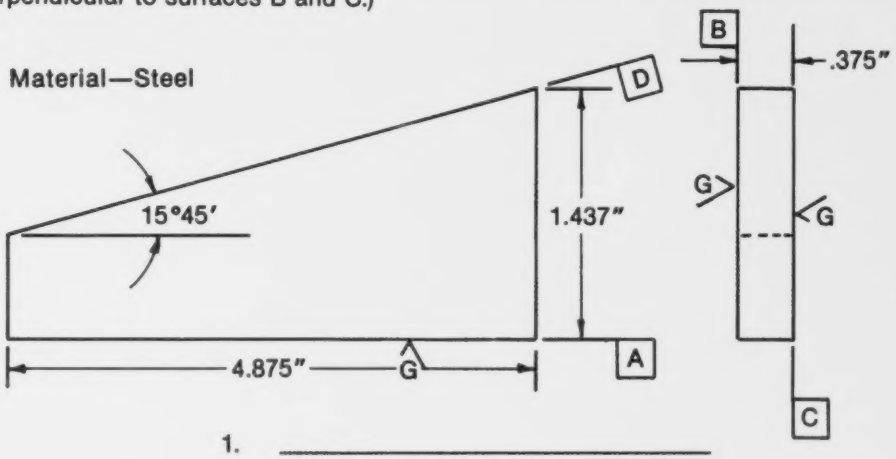
1. _____
2. _____

ASSIGNMENT SHEET #1

Magnetic chuck
Connetic V-block
Connetic parallels
Magnetic V-block
V-block and clamp
Angle plate, clamp, and adjustable parallel
Magnetic sine chuck
Adjustable angle vise
Angle plate, clamps, and sine bar
Magna-vise clamps

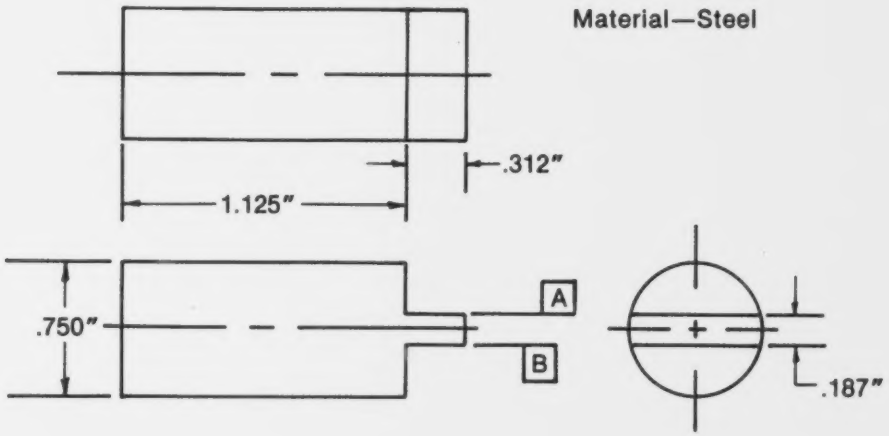
G. Grinding the angular surface D at a 15-degree 45-minute angle to surface A

(NOTE: Surfaces A, B, and C have been ground flat with B and C parallel and surface A perpendicular to surfaces B and C.)



1. _____
2. _____
3. _____

H. Grinding surfaces A and B parallel and centered on the round steel rod

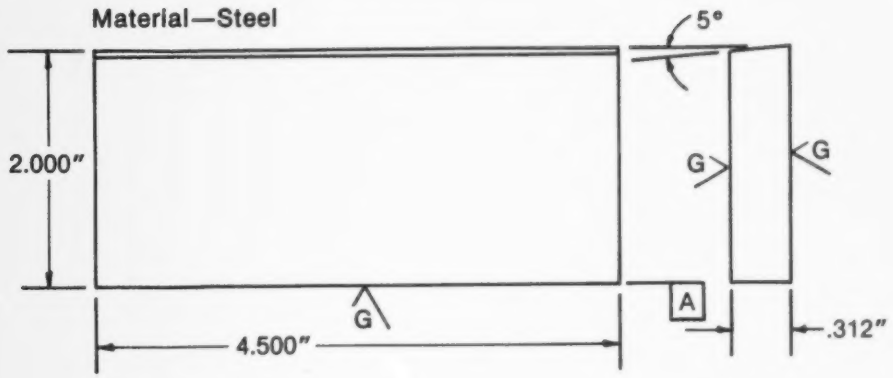


1. _____
2. _____

ASSIGNMENT SHEET #1

Magnetic chuck
Connetic V-block
Connetic parallels
Magnetic V-block
V-block and clamp
Angle plate, clamp, and adjustable parallel
Magnetic sine chuck
Adjustable angle vise
Angle plate, clamps, and sine bar
Magna-vise clamps

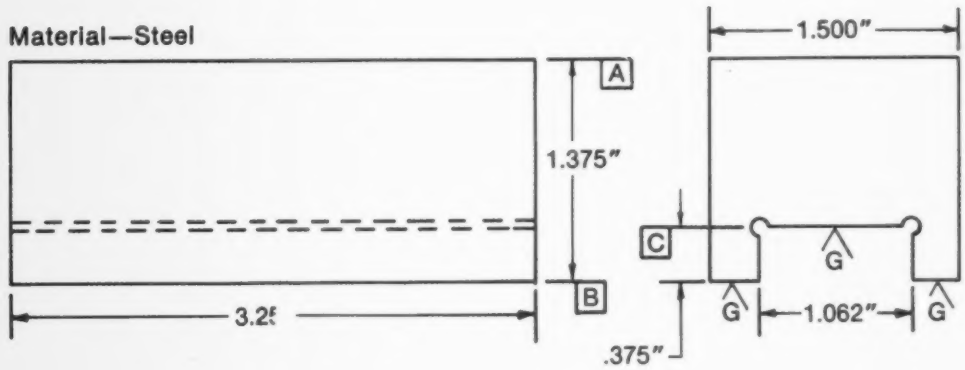
I. Grinding a 5-degree angle parallel to surface A



1. _____

2. _____

J. Grinding surfaces B and C parallel to surface A, which has been previously ground



1. _____

2. _____

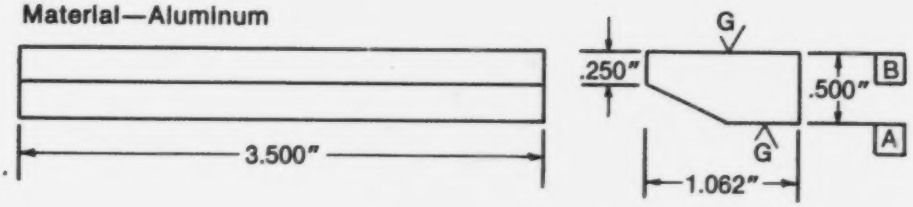
ASSIGNMENT SHEET #1

Magnetic chuck
Connetic V-block
Connetic parallels
Magnetic V-block
V-block and clamp
Angle plate, clamp, and adjustable parallel

Magnetic sine chuck
Adjustable angle vise
Angle plate, clamps, and sine bar
Magna-vise clamps

K. Grinding surface B parallel to surface A

Material—Aluminum



1. _____

2. _____

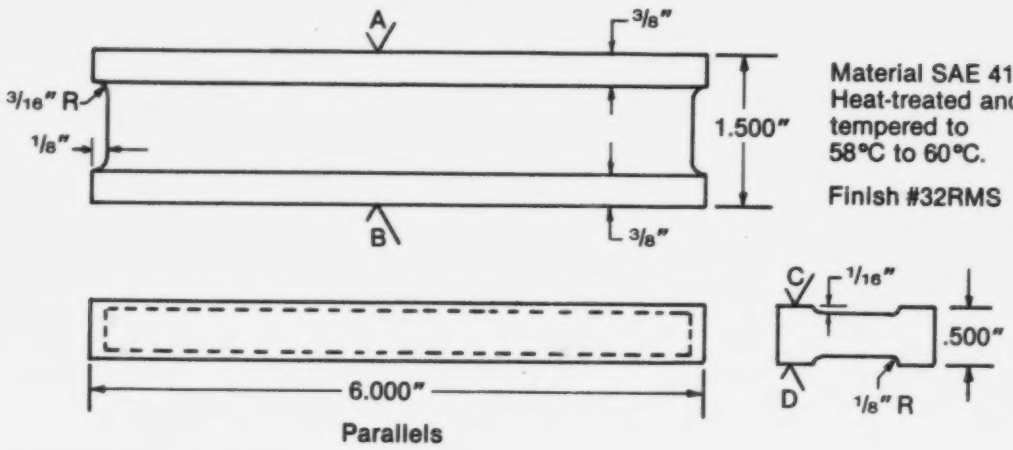
SURFACE GRINDING
UNIT II

ASSIGNMENT SHEET #2 — PLAN PROCEDURES TO GRIND PARALLELS

NAME _____ SCORE _____

The machinist who has the ability to plan the production of a part by determining ahead of time the best setup, the proper grinding wheel, and the most efficient sequence of operations saves time and works more effectively.

Study the following plans for a set of parallels, and then complete the exercises that follow.



Parallels

(NOTE: Grinder is equipped with magnetic chuck and flood coolant.)

ASSIGNMENT SHEET #2

A. What types and compositions of grinding wheels are required to grind the 0.500- and 1.500-inch dimensions? Assume that each surface has 0.020 inch of material remaining to be ground to the finished dimension.

1. Types of grinding wheels

   a. Rough — _____

   b. Finish — _____

2. Compositions (abrasive, grade, grit, and bond)

   a. Rough — _____

   b. Finish — _____

B. List the other tools and equipment required to grind the 0.500- and 1.500-inch dimensions.

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

ASSIGNMENT SHEET #2

C. List in sequence the steps required to machine surfaces A, B, C, and D to the required dimensions and finish.

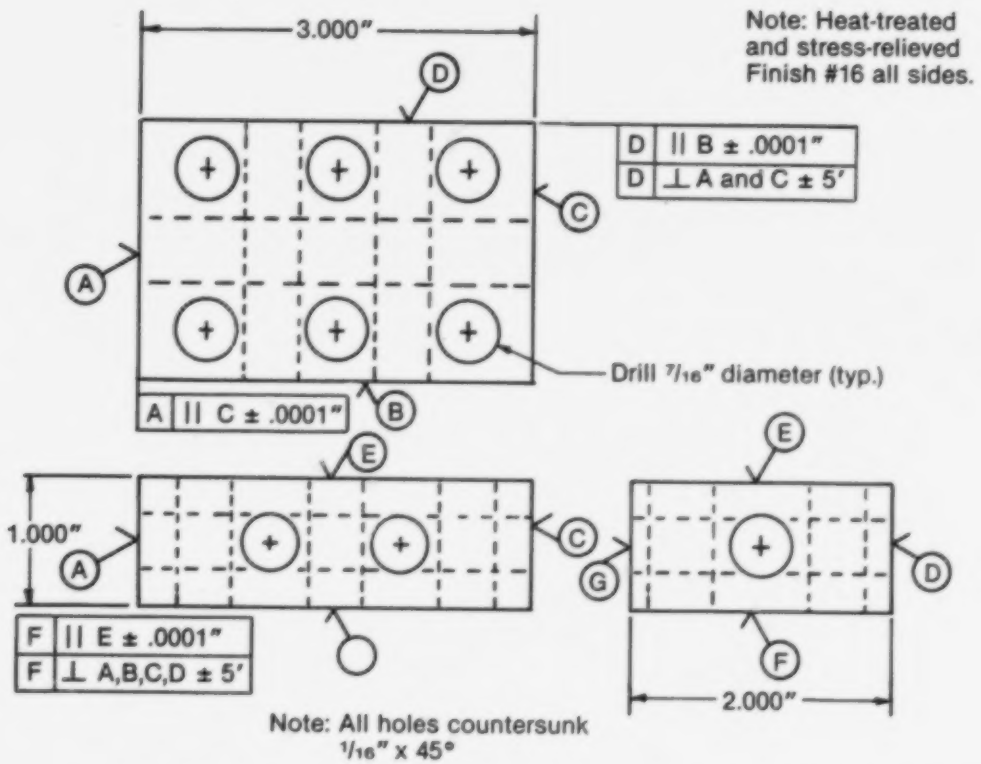
SURFACE GRINDING
UNIT II

ASSIGNMENT SHEET #3 — PLAN PROCEDURES TO GRIND A SET OF SETUP BLOCKS

NAME _____ SCORE _____

Planning is something that you must learn, and practice in procedure planning will help you become a better machinist.

Study the plans for the setup block shown below, and then complete the exercises that follow.



(NOTE: Letters A through F are for surface reference only and do not indicate grinding sequence.)

ASSIGNMENT SHEET #3

A. List the tools and work-holding devices required to grind the blocks to finished dimensions. Assume that the blocks have been scaled and drilled and that the machine being used is equipped with a magnetic chuck, coolant, and a 32A46-J8VBE Type #1 wheel.

B. List the procedures required to grind the blocks to size. Assume that 0.020 inch of material remains to be ground from each surface.

ASSIGNMENT SHEET #3

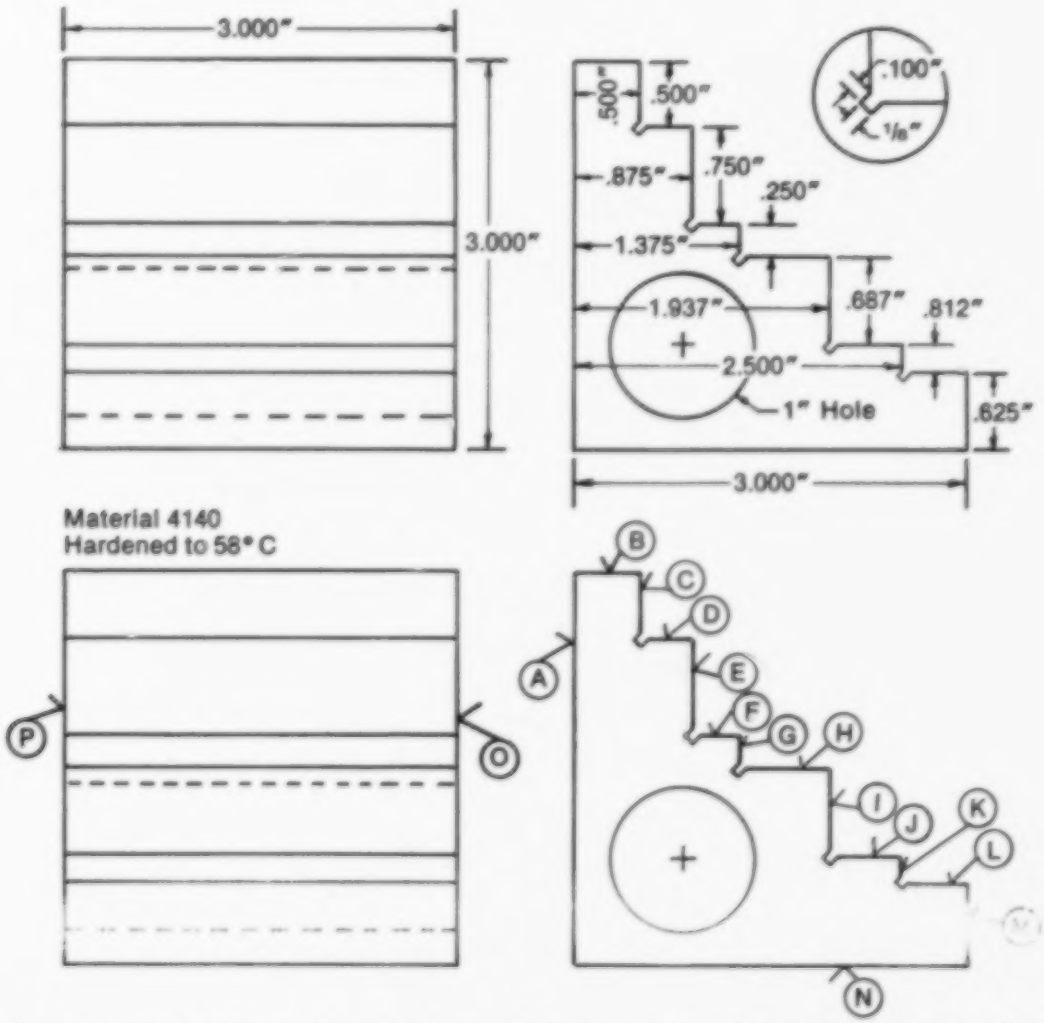
SURFACE GRINDING
UNIT II

ASSIGNMENT SHEET #4 — PLAN PROCEDURES
TO GRIND A STEP ANGLE PLATE

NAME _____ SCORE _____

The more thought you give to a job before starting work, the smoother the procedure will go. Always plan a job before starting.

The drawing below shows the plans for a step angle plate. Study the drawings, and then complete the exercises that follow.



(NOTE: Letters A through P are for surface reference only and do not indicate grinding sequence.)

ASSIGNMENT SHEET #4

A. List the tools and equipment necessary to grind the step angle plate.

B. List in order the procedures required to grind the step angle plate.

ASSIGNMENT SHEET #4

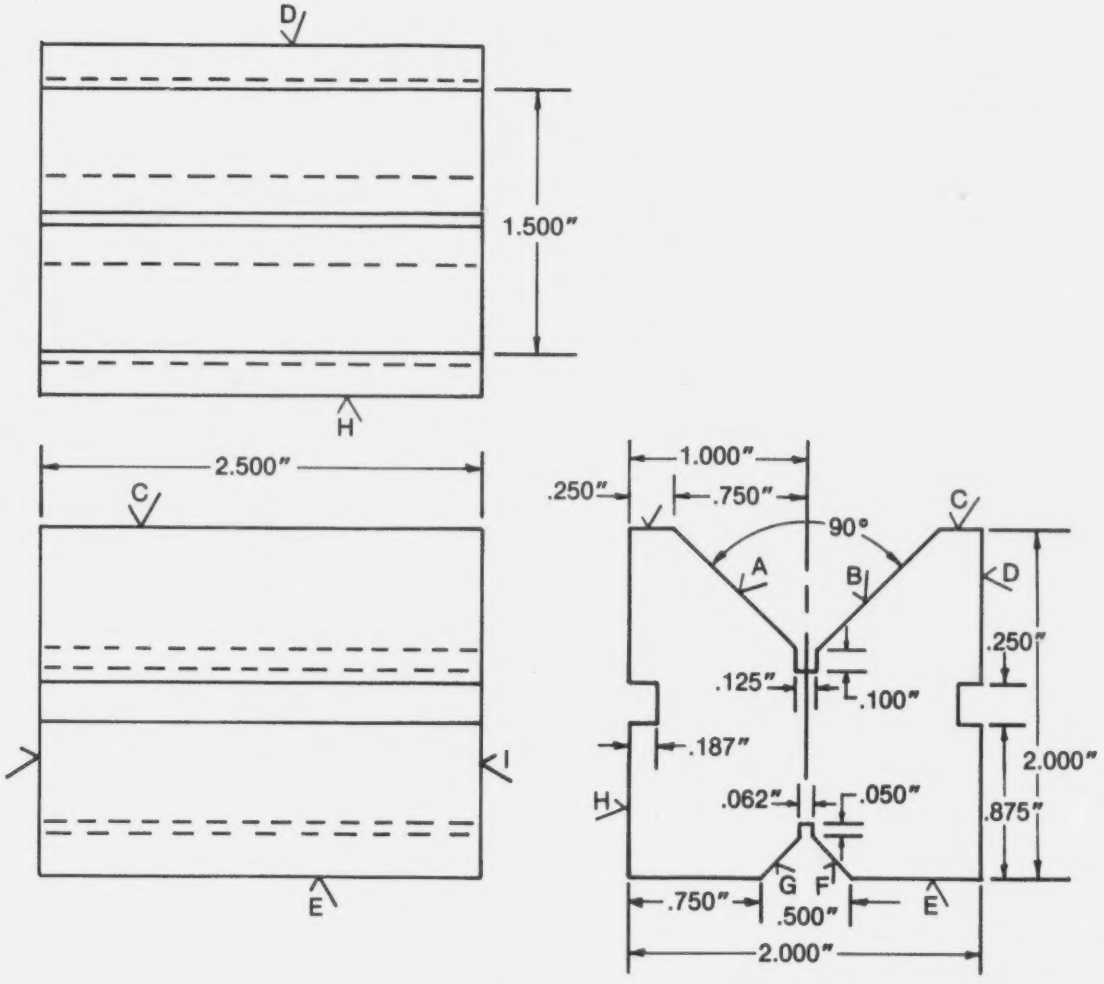
SURFACE GRINDING
UNIT II

ASSIGNMENT SHEET #5 — PLAN PROCEDURES
TO GRIND A V-BLOCK

NAME _____ SCORE _____

The more complicated the production process is, the more important it is that you carefully plan the operations required. Parts with many surfaces, angles, and different types of grinding requirements present special problems in planning.

Study the plans for a V-block shown below, and then complete the exercises that follow.



(NOTE: Letters A through J are for surface reference only and do not represent grinding sequence.)

ASSIGNMENT SHEET #5

A. List the tools and equipment required to grind the V-block. Assume that the workpiece is ready for final grinding with 0.020 inch of material left to be removed from each indicated surface. The grinding machine has a magnetic chuck, coolant, and a 32A46-J8VBE Type #1 wheel.

B. List in order the procedures required to grind the V-block.

ASSIGNMENT SHEET #5

SURFACE GRINDING
UNIT II

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A.
1. Magnetic chuck
2. Magna-vise clamps
3. Connetic parallels

B.
1. Angle plate, clamp, and adjustable parallel
2. Connetic parallels

C.
1. Connetic parallels
2. Magnetic chuck
3. Magna-vise clamps

D.
1. Magnetic sine chuck
2. Adjustable angle vise
3. Angle plate, clamps, and sine bar

E.
1. Connetic V-block
2. Adjustable angle vise
3. Magnetic V-block

F.
1. Magnetic V-block
2. Connetic V-block

G.
1. Angle plate, clamps, and sine bar
2. Adjustable angle vise
3. Magnetic sine chuck

H.
1. V-block and clamp
2. Connetic V-block

ANSWERS TO ASSIGNMENT SHEETS

I. 1. Magnetic sine chuck
2. Adjustable angle vise

J. 1. Magnetic chuck
2. Magna-vise clamps

K. 1. Magna-vise clamps
2. Magnetic chuck

Assignment Sheet #2

(NOTE: The tools, equipment, and procedures may vary depending on availability of tools and equipment, and instructor's preferences.)

A. 1. a. Type #1
b. Type #1
2. a. 32A46-J8VBE
b. AA60-G8V40

B. 1. Angle plate, 4-inch
2. Steel rule, 6-inch
3. C-clamp, 4-inch
4. Vernier micrometer, 0- to 2-inch
5. Dressing block and diamond
6. Surface plate
7. Micrometer, 1- to 2-inch
8. Adjustable parallels
9. Depth micrometer
10. Screwdriver
11. Dressing stick
12. Soft oilstone
13. Hard oilstone

C. 1. Dress wheel flat
2. Clean magnetic chuck
3. Check for burrs on surface of magnetic chuck; remove by honing if necessary; reclean work surface

ANSWERS TO ASSIGNMENT SHEETS

4. Place side C or D of one parallel on magnetic chuck, energize chuck, and grind top surface
5. Remove parallel and deburr
6. Place side C or D of second parallel on magnetic chuck, energize chuck, and grind top side
7. Remove parallel and deburr
8. Clean chuck, and place the two parallels on magnetic chuck with ground side on chuck
9. Energize chuck, and grind the two parallels until surfaces are smooth and flat
10. Measure thickness with depth micrometer; grind thickness to 0.500 inch
11. Remove parallels from chuck; use soft oilstone to deburr surface just ground
12. Adjust parallels to a height of 2⅝ inches
13. Place angle plate on surface plate, place adjustable parallels against upright face of angle plate, and place surface A or B on adjustable parallel
14. Clamp parallel in place with C-clamps; place angle plate on magnetic chuck, and grind top surface smooth and flat
15. Remove first parallel, and repeat procedure to grind top surface of second parallel
16. Remove parallel from magnetic chuck, and deburr edges of surfaces just ground; clean magnetic chuck
17. Place both parallels on chuck with unground side up; grind smooth and flat
18. Measure height of parallels, and grind surface to dimension of 1.500 inches
19. Remove parallels, and deburr surfaces just ground
20. Inspect workpieces

Assignment Sheet #3

(NOTE: The tools, equipment, and procedures may vary depending on availability of tools and equipment, and instructor's preference.)

A.
1. Angle plate (4-inch) with C-clamps
2. Surface plate
3. Adjustable parallels
4. Height gauge with indicator
5. Dressing stick
6. Dressing block and diamond
7. Micrometer, 1- to 2-inch
8. Micrometer, 2- to 3-inch
9. Micrometer, 3- to 4-inch
10. Soft oilstone
11. Hard oilstone
12. Grinding paper
13. Ground parallel, 1" x 2" x 5"
14. Small plastic mallet

ANSWERS TO ASSIGNMENT SHEETS

B.

1. Dress wheel flat; clean magnetic chuck
2. Check for burrs on surface of magnetic chuck; remove by honing if necessary; reclean work surface
3. Place on magnetic chuck side E or F of one block; grind the opposite side
4. Perform same operation on second block
5. Deburr edges of surfaces just ground; clean magnetic chuck
6. Place ground surfaces of both blocks on magnetic chuck; grind to a dimension of 1.000 inch
7. Remove workpieces, clean chuck, and deburr edges of surface just ground
8. Redress grinding wheel
9. Adjust the parallel to about 2⅛ inches
10. Place angle plate on surface plate, place adjustable parallel on vertical surface of angle plate, place surface B or D on parallel, and clamp block to angle plate
11. Place angle plate on chuck, grind surface B or D smooth and flat, remove angle plate from chuck, and clean chuck
12. Unclamp block, clean angle plate, and repeat steps 9 and 10 with second block
13. Deburr edges, and place both blocks on chuck so that surfaces just ground are down
14. Grind blocks to a dimension of 2.000 inches; remove from chuck, clean chuck, and deburr surfaces just ground
15. Redress grinding wheel
16. Place angle plate so that both faces are vertical on surface plate; slide adjustable parallel up to one of vertical surfaces; place surface B or D on parallel so that surface A or C is about ⅛ inch above top of angle plate; clamp in place
17. Remove adjustable parallel; check surface with dial indicator to see that it is parallel to surface plate; adjust if necessary
18. Place angle plate on chuck so that surface A or C is up; grind the surface smooth and flat
19. Repeat steps 15, 16, and 17 on second block; deburr edges of surfaces just ground; clean chuck
20. Place surfaces just ground on magnetic chuck with the 1-by-2-inch parallel between the two blocks so that the 1-inch surface of parallel is on chuck
21. Hold the two blocks firmly against the parallel and energize chuck; clamp the blocks together
22. Grind the two surfaces to a dimension of 3.000 inches
23. Remove workpiece from chuck, unclamp, and deburr surfaces just ground
24. Inspect workpieces

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #4

(NOTE: The tools, equipment, and procedures may vary depending on availability of tools and equipment, and instructor's preferences.)

A.

1. Angle plate (4-inch) with sides ground
2. Two C-clamps, 4-inch
3. Surface plate
4. Parallel, 1" x 1/2" x 6"
5. Hard oilstone
6. Soft oilstone
7. Clean rag
8. Height gauge with indicator
9. Dressing stick
10. Dressing block with diamond
11. Depth micrometer, 0- to 3-inch
12. Grinding paper
13. Small plastic mallet

B.

1. Dress wheel flat; clean chuck
2. Check for burrs on surface of chuck; remove by honing if necessary; reclean work surface
3. Place angle plate on surface plate; place parallel on surface plate with 1-inch surface down; slide it up so that 1/2-inch edge is against vertical surface of angle plate
4. Place surface B or M on parallel so that surface A or N is against vertical surface of angle plate, with side P or O extending about 1/8 inch past side of angle plate; clamp so that surface A or N can be ground
5. Place angle plate on magnetic chuck; grind surface A or N smooth and flat
6. Move to the top one clamp on side, and then move the other clamp
7. Rechuck angle plate on side so that surface P or O is up; grind that surface
8. Remove workpiece from chuck; unclamp and clean angle plate and magnetic chuck; deburr edges of surface just ground
9. Place angle plate on surface plate so that it is to one side
10. Place surface P or O on surface plate, then place part so that surface A or N is against vertical surface of angle plate about 1/8 inch above top surface of angle plate
11. Clamp with C-clamps so that surface A or N can be ground
12. Redress grinding wheel
13. Place angle plate on chuck; grind surface A or N
14. Remove workpiece from chuck, unclamp, and deburr edges of surface just ground
15. Clean chuck, and place workpiece on chuck so that ground surface P or O is on chuck; grind surface P or O smooth, flat, and to dimension of 3.000 inches

ANSWERS TO ASSIGNMENT SHEETS

16. Remove workpiece from chuck; deburr edges of surface just ground
17. Redress grinding wheel; clean chuck
18. Place 1-inch surface of parallel on chuck so that ½-inch edge is in contact with backstop of magnetic chuck
19. Place workpiece on chuck so that surface N is on chuck and surface A is against parallel at left end of chuck
20. Place dressing block with diamond near right end of chuck; energize chuck
21. Grind surface B smooth, flat, and to dimension of 3.000 inches
22. Grind surface D smooth and flat to dimension by cranking wheel down a total of 0.500 inch; however, the total depth should not be taken in one cut
23. Continue to cut surfaces F, H, J, and L to dimension, using procedures explained in step 22; however, downfeed dimension will change with surface being ground
24. Redress grinding wheel, and repeat steps 21 to 23
25. Rechuck workpiece with surface A down and surface N against parallel; grind surfaces M, K, I, G, E, and C, using the same procedures as in steps 21 through 24
26. Remove workpiece from chuck, deburr edges of all ground surfaces, inspect workpiece, and clean machine

Assignment Sheet #5

(NOTE: The tools, equipment, and procedures may vary depending on availability of tools and equipment, and instructor's individual preferences.)

A.
1. Angle plate (4-inch) with ground sides
2. C-clamps, 4-inch
3. Adjustable parallels
4. Height gauge with indicator
5. Dressing stick
6. Dressing block and diamond
7. Micrometer, 2- to 3-inch
8. Soft oilstone
9. Hard oilstone
10. Grinding paper
11. Small plastic mallet
12. Parallel, ½" × 1" × 6"
13. Magnetic V-block

B.
1. Dress wheel flat; clean magnetic chuck
2. Check for burrs on surface of chuck; remove by honing if necessary; reclean work surface

ANSWERS TO ASSIGNMENT SHEETS

3. Place surface C or E on chuck; grind opposite side

4. Place ground surface down; grind opposite side to dimension of 2.000 inches

5. Place workpiece on angle plate with side E against vertical surface of angle plate and surface D or H parallel to surface plate; clamp in place

6. Grind surface D or H, remove workpiece from angle plate, and deburr edges of surfaces ground

7. Place surface just ground on chuck; grind opposite side to a dimension of 2.000 inches; unchuck and deburr

8. Clamp one of four ground sides to angle plate, and align parallel to surface plate

9. Grind surface I or J, remove workpiece from angle plate, and deburr edges

10. Place surface I or J on chuck; grind opposite surface to a dimension of 2.500 inches; unchuck and deburr

11. Place magnetic V-block on magnetic chuck; align parallel to table travel; energize chuck to hold V-block true

12. Place surfaces D and E in magnetic V-block and energize

13. Grind surface B flat and smooth; zero the downfeed or note the setting

14. Turn workpiece in magnetic V-block so that surfaces E and H are in "V"; energize V-block

15. Grind surface A to same setting

    (NOTE: It may be necessary to turn workpiece and grind surface B again.)

16. Redress wheel flat

17. Grind surfaces G and F, using same procedures as those used for surface A and B

18. Remove burrs from edges of ground surfaces

19. Inspect workpiece for accuracy

SURFACE GRINDING
UNIT II

JOB SHEET #1 — REMOVE AND REPLACE A GRINDING WHEEL

I. Equipment and materials

A. Surface grinding machine

(NOTE: These procedures apply to the Brown and Sharpe 618 Micromaster. The procedures may differ with other machines. Refer to the operator's manual.)

B. Type #1 straight grinding wheel

C. Adapter (wheel)

D. Spanner wrench to fit adapter

E. Puller (adapter)

F. Wrench to fit spindle nut

G. Wrench to fit puller

H. Plastic-handled screwdriver

I. Clean cloths

J. Wire brush

K. Oilstone

L. Soft pine block, 1" × 2" × 6"

II. Procedure for removing and replacing wheel mounted on wheel sleeve

A. Remove grinding wheel from wheel sleeve

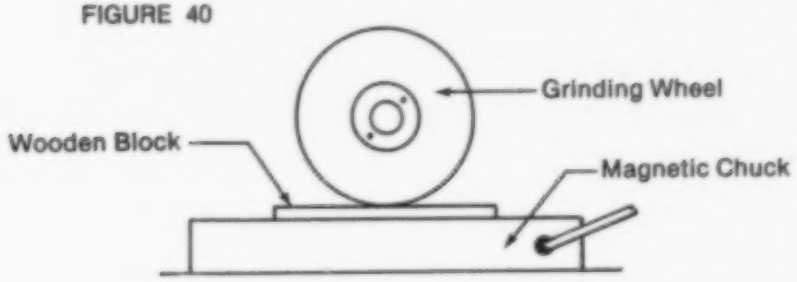
1. Turn power disconnect switch to OFF

2. Remove wheel-guard retaining screw, and remove wheel guard

(NOTE: Some wheel guards are hinged. On this type, remove retaining screws and turn guard out of the way.)

3. Place wooden block on chuck, and crank wheel down against block with just enough pressure to keep wheel from slipping when loosening wheel-sleeve nut (Figure 40)

FIGURE 40



4. Insert pin spanner wrench in holes of wheel sleeve; hold grinding wheel with one hand, and turn spanner wrench clockwise to loosen wheel-sleeve nut

   (NOTE: Wheel-sleeve nut has left-hand threads.)

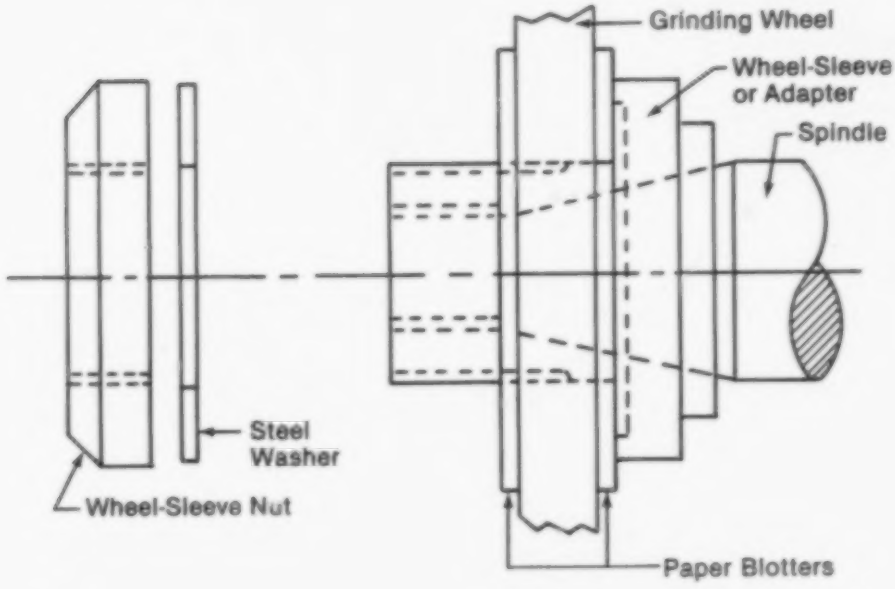
5. Remove wheel-sleeve nut and place it on bench

6. Raise wheel, and remove wooden block

7. Remove the steel disc or washer (Figure 41)

   (NOTE: The washer is keyed to the sleeve to prevent slippage of the washer, which might loosen the clamping nut.)

FIGURE 41



JOB SHEET #1

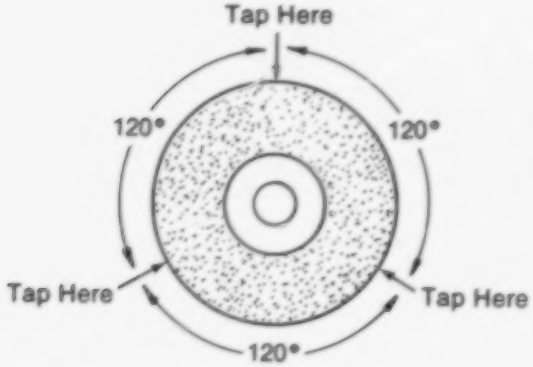
8. Remove grinding wheel and place on storage board

B. Mount grinding wheel on wheel sleeve

1. Wrap a clean cloth around wheel sleeve
2. Use wire brush to clean inside of wheel guard; wipe with another clean cloth to remove any loose grinding dirt or particles
3. Remove cloth from wheel sleeve, and clean spindle and fixed flange
4. Clean fixed flange of burrs
5. Remove all burrs with a stone before continuing
6. Before mounting grinding wheel, hold it in front of you, supported on one finger; with handle of screwdriver, lightly tap edge of wheel in three places about 120 degrees from each other (Figure 42)

   (NOTE: Each time the wheel is tapped, it should produce a clear ring. If wheel does not ring clear, check with your instructor to determine whether it should be discarded.)

   FIGURE 42



7. Wipe out mounting hole, and slide wheel on wheel sleeve

   (CAUTION: If the grinding wheel does not slide on easily, do not force or alter hole; get another wheel.)

8. Slide on steel washer
9. Start wheel-sleeve nut by turning nut counterclockwise; finger-tighten
10. Place wooden block on chuck; lower wheel against board

11. Place wrench on spindle nut, and place pin spanner in the two holes; tighten wheel-sleeve nut

    (CAUTION: Overtightening of wheel-sleeve nut can crack the wheel.)

12. Replace wheel-guard cover

13. Turn power disconnect switch to ON

14. Start wheel and allow to run for one minute before dressing

    (NOTE: Any time a wheel is changed, it must be trued with a diamond before attempting a grinding operation.)

III. Procedure for removing and replacing wheel and wheel sleeve as a unit

A. Remove grinding wheel and wheel sleeve as a unit

1. Turn power disconnect switch to OFF

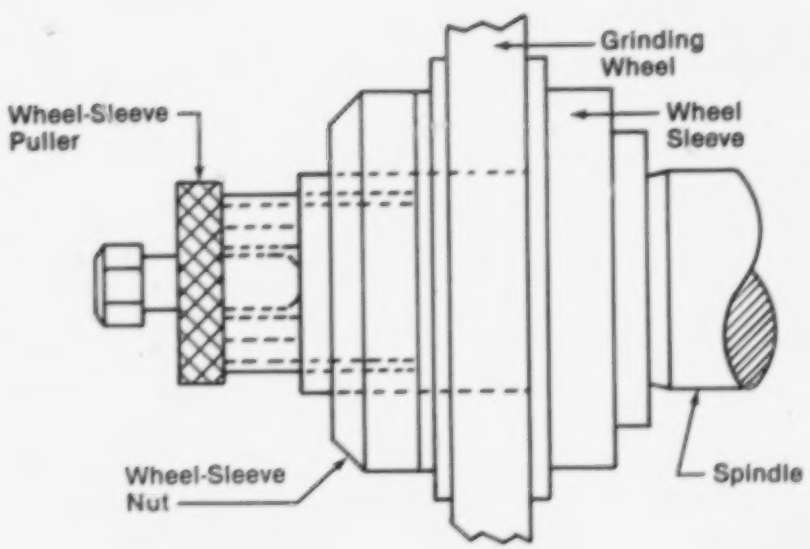
2. Remove wheel guard

3. Place spindle-nut wrench on spindle; hold grinding wheel, and turn spindle nut counterclockwise; remove nut

4. Thread wheel-sleeve puller onto wheel sleeve, and turn inner screw until it disengages wheel sleeve from tapered spindle (Figure 43)

   (CAUTION: Never try to remove wheel sleeve by pounding. The wheel could be cracked, or the spindle bearings could be damaged.)

FIGURE 43



JOB SHEET #1

5. Remove grinding wheel and wheel sleeve

6. Unscrew wheel-sleeve puller

7. Place grinding wheel and wheel sleeve on storing board; return wheel-sleeve puller to proper storage place

B. Mount grinding wheel and wheel spindle unit

1. Wrap cloth around spindle

2. Use wire brush and clean cloth to remove any grinding particles and dust from wheel guard

3. Clean spindle and tapered portion of wheel sleeve; place on spindle

4. Start spindle clamping nut by turning counterclockwise; snug spindle nut with wrench

5. Replace wheel guard

6. Turn on main power, start spindle, and allow wheel to run for one minute before dressing

   (NOTE: Wheels that have been used and removed with wheel sleeve should run true; however, they should be dressed lightly before using.)

7. Clean machine and work area; put away all tools

SURFACE GRINDING
UNIT II

JOB SHEET #2 — DRESS A WHEEL FLAT

I. Equipment and materials

A. Surface grinder with coolant and magnetic chuck

B. Single-point diamond mounted in holder

C. Clean cloth

D. Grinding paper

E. Goggles or approved eye protection

F. Dressing stick

G. Type #1 AA46-J8V40 grinding wheel

II. Procedure

A. Check diamond point for wear; rotate diamond in holder if point is rounded

B. Clean magnetic chuck with a clean cloth, and then wipe with palm of hand to remove any grit

C. Place a piece of grinding paper slightly larger than the holder base near center of left half of magnetic chuck

JOB SHEET #2

D. Place diamond holder on grinding paper and energize chuck; check that holder is secure

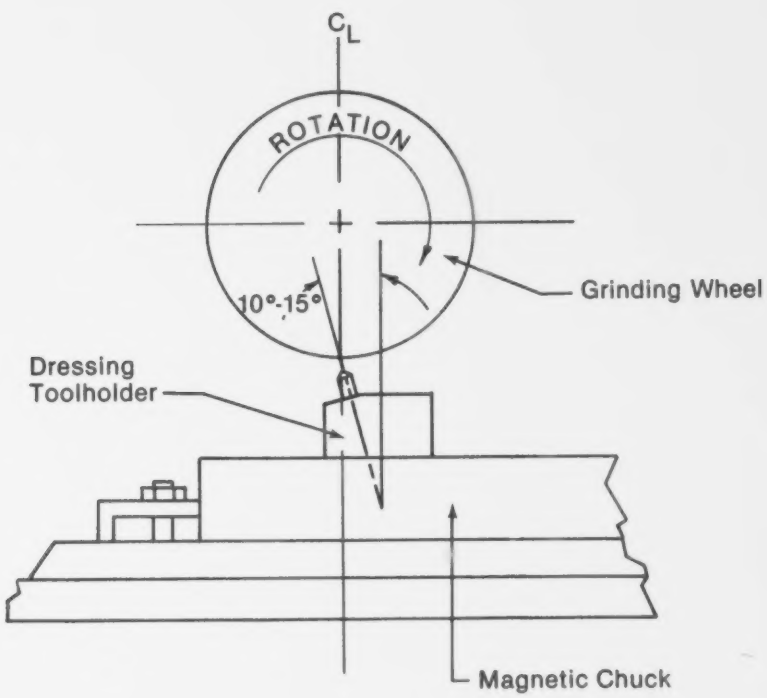
(NOTE: The paper will allow the dresser to be removed easily without scratching the surface of the magnetic chuck.)

E. Raise wheel 1 inch above height of diamond

F. Move table longitudinally so that point of diamond is on centerline of wheel or slightly left of center (Figure 44)

(CAUTION: The diamond should be canted 10 to 15 degrees in direction of wheel rotation.)

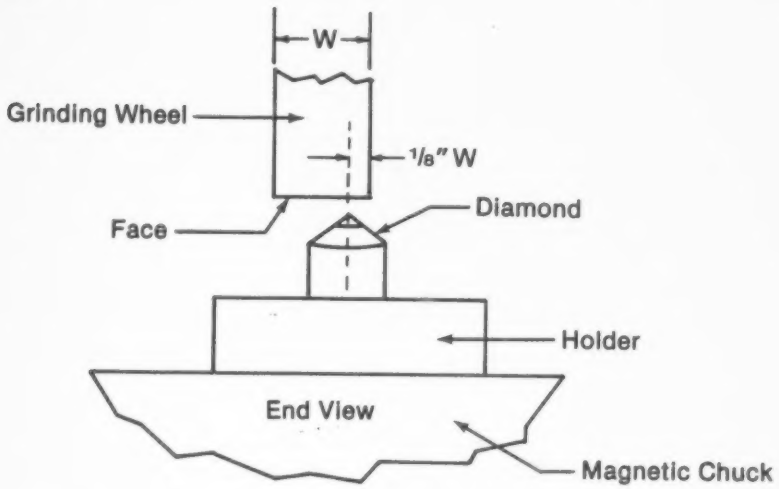
FIGURE 44



JOB SHEET #2

G. Crank cross feed, and position diamond under point of deepest wear (Figure 45)

FIGURE 45



H. Lower wheel carefully until it just touches diamond

I. Crank cross feed clockwise until face of wheel has cleared diamond

J. Lower wheel 0.001 inch, and crank cross feed counterclockwise at a medium rate until diamond is on other side of wheel

K. Continue to down feed wheel 0.001 inch until face has been dressed completely flat

L. Move cross feed so that diamond is clear of grinding wheel (front side), deenergize chuck, and remove diamond

(NOTE: The wheel is moved over the diamond only one time per cut. Feeding the wheel slower reduces the cutting rate of the wheel but improves the finish. A fast rate increases the cutting rate of the wheel and produces a coarser finish on the workpiece.)

M. Hold dressing stick firmly in both hands at a slight angle; gently dress ragged edges from front and back sides of wheel

(NOTE: The wheel should be dressed in the same condition it is going to be used. Wet grinding requires dressing the wheel with coolant on; dry grinding requires dressing the wheel without coolant.)

N. Clean machine and work area; put away all tools

SURFACE GRINDING
UNIT II

JOB SHEET #3 — GRIND A WORKPIECE FLAT AND PARALLEL

I. Equipment and materials

A. Grinding machine with power feeds in longitudinal and cross-feed directions, coolant, and magnetic chuck (mounted)

B. Single-point diamond mounted in holder

C. Clean cloth or squeegee

D. Hard oilstone

E. Medium oilstone

F. Micrometer, 1- to 2-inch

G. Steel block, 2″ × 2″ × 5″ premachined square and heat-treated between 55 C to 60 C

H. Abrasive cloth, 120-grit, 2-by-6-inch

I. Type #1 32A60-J8VBE or equivalent grinding wheel (mounted)

J. Grinding paper

K. Pencil

II. Procedure

A. Dress grinding wheel wet

B. Clean magnetic chuck and hone lightly to remove any burrs

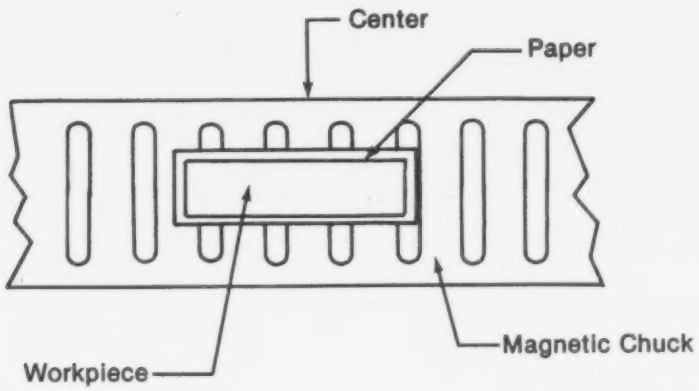
C. Sand all sides of steel block to remove any scale caused by heat-treatment

D. Place a piece of grinding paper slightly larger than the workpiece in the center of the chuck

JOB SHEET #3

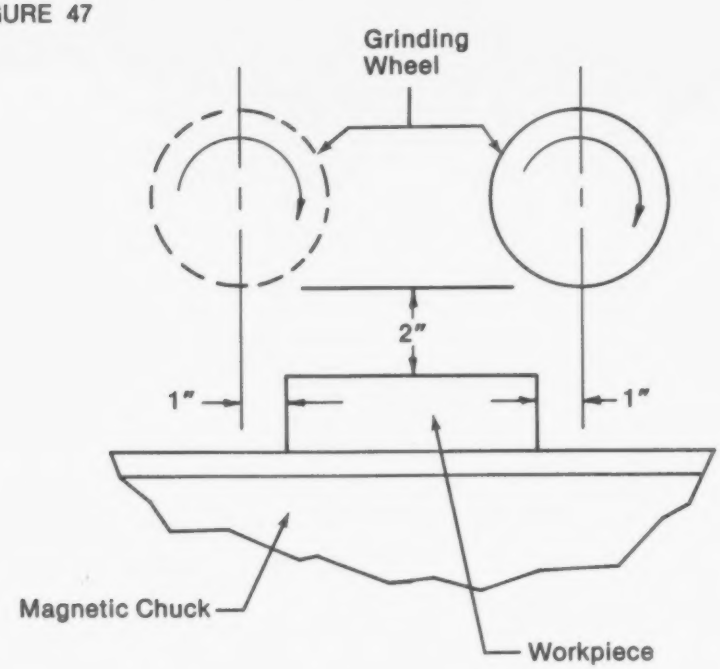
E. Place workpiece on paper with its length parallel to length of chuck; energize chuck, and check workpiece to see that it is held securely (Figure 46)

FIGURE 46



F. Adjust table reverse dogs so that center of wheel clears each end of workpiece 1 inch (Figure 47)

FIGURE 47



JOB SHEET #3

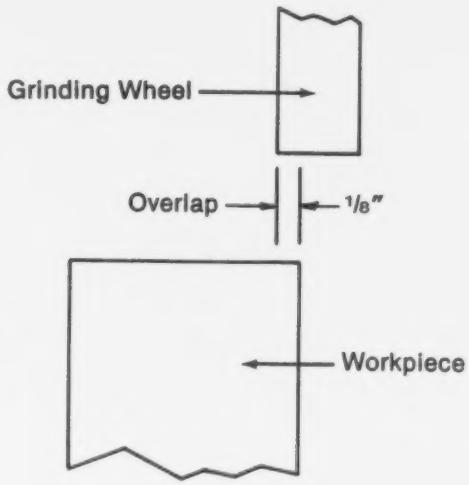
G. Turn machine on; adjust table travel to 25 inches per minute

H. Set cross-feed movement at 0.030 inch per table direction change

I. Disengage power table feed, and put cross-feed lever in NEUTRAL position

J. Adjust table by hand until edge of the wheel overlaps workpiece 1/8 inch (Figure 48)

FIGURE 48



K. Start grinder, and lower wheel slowly until it just sparks workpiece

L. Engage fine-feed knob, and raise wheel 0.005 inch to clear any high spots on work

M. Start coolant; allow it to run for one minute to stabilize wheel

N. Move table longitudinally while feeding workpiece rapidly across face of wheel

O. Move wheel so that it clears the back side of workpiece; lower wheel 0.005 inch

P. Start table moving by power, and engage cross-feed lever so that wheel will move over workpiece

Q. Allow grinder to grind top surface

R. Stop power table feed and cross feed

JOB SHEET #3

S. Position table by hand so that wheel will not cut workpiece

T. Crank cross feed to back side of workpiece

U. Lower wheel 0.001 inch, and make another cut

V. Repeat steps O through Q until surface is smooth

W. Turn off coolant, stop table travel, and allow wheel to run for one minute to remove coolant from pores of wheel

X. Stop machine

Y. Position wheel on back side of workpiece with table near left trip dog; mark location of workpiece with pencil

(CAUTION: Do not crank wheel over finished work; the wheel may scratch surface.)

Z. Release workpiece and remove from magnetic chuck

AA. Wipe chuck with clean rag or squeegee; then wipe with palm of hand to remove any dirt and to check for smoothness

BB. Place a clean piece of grinding paper on chuck

CC. Use medium oilstone to remove burrs from edges of surface just ground

(CAUTION: These steel slivers are sharp. Take care not to cut yourself.)

DD. Place workpiece on grinding paper with ground side down; energize chuck, and repeat procedure to grind second side flat

(NOTE: Do not change adjustment of grinding-wheel height. You can start grinding from that point.)

EE. Check for parallelism by measuring all four corners of workpiece

(NOTE: The micrometer reading should be the same in all locations. If workpiece is not true, you may need to redress wheel and regrind second side.)

FF. Clean machine and work area; put away all tools

SURFACE GRINDING
UNIT II

JOB SHEET #4 — GRIND A WORKPIECE SQUARE

I. Equipment and materials

A. Surface grinder with magnetic chuck and coolant

B. Precision angle plate

C. Two C-clamps, 4-inch

D. Grinding paper

E. Single-point diamond mounted in holder

F. Dressing stick

G. Clean cloth or squeegee

H. Hard oilstone

I. Medium oilstone

J. Steel block

(NOTE: This is the same material used for Job Sheet #3.)

K. Type #1 32A60-J8VBE or equivalent grinding wheel (mounted)

L. Surface plate

M. Adjustable parallels

N. Steel rule, 6-inch

O. Screwdriver to fit adjustable parallels

P. Micrometer, 1- to 2-inch

II. Procedure

A. Dress grinding wheel

B. Clean chuck and remove any burrs with hard oilstone; wipe top surface of chuck with your hand to remove any dirt and to check for smoothness

C. Place piece of grinding paper slightly larger than base of angle plate near center of magnetic chuck

JOB SHEET #4

D. Clean surface plate and place on clean cloth

E. Clean angle plate and check for burrs; remove any burrs with hard oilstone; place angle plate on surface plate

F. With steel rule, measure thickness of workpiece between surfaces ground in Job Sheet #3

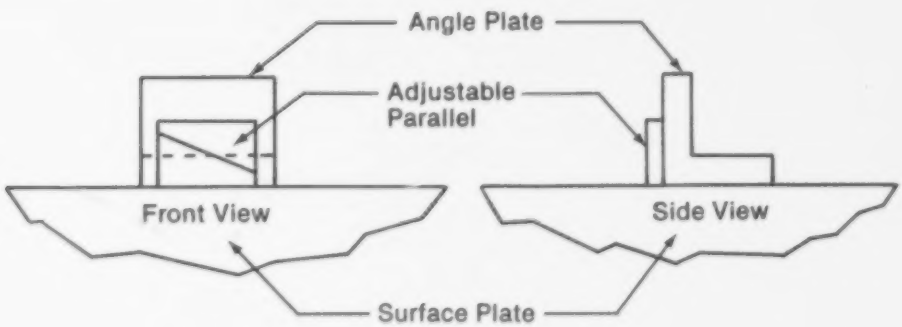
G. Measure height of angle plate with steel rule, and subtract thickness of workpiece from height of angle plate

H. Select an adjustable parallel with a range greater than difference between thickness of workpiece and height of angle plate; set adjustable parallel about 1/8 inch larger than that difference

(NOTE: The adjustable parallel will raise the workpiece above the top surface of the angle plate and place the workpiece parallel to the magnetic chuck.)

I. Place parallel on surface plate so that it is next to upright surface of angle plate (Figure 49)

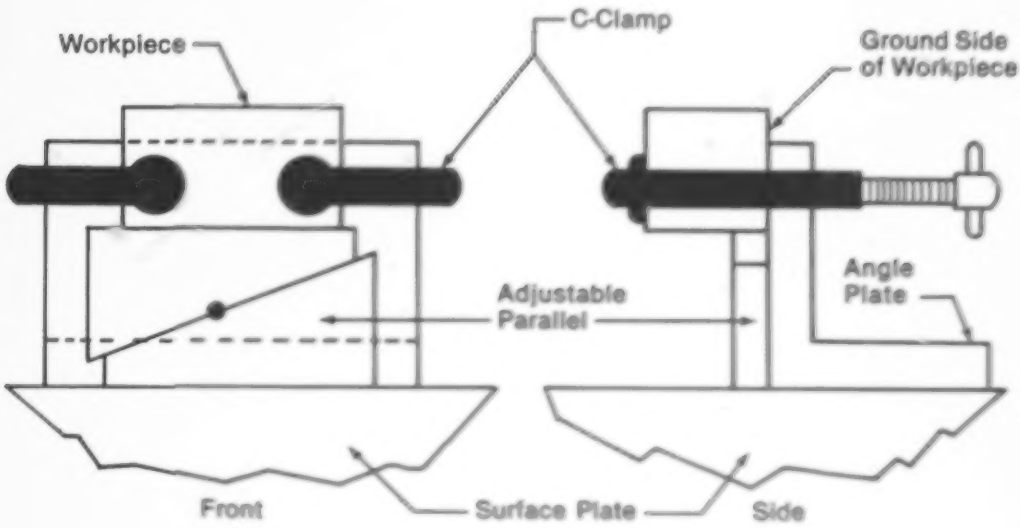
FIGURE 49



JOB SHEET #4

J. Place workpiece on adjustable parallel with one of the ground sides against upright surface of angle plate; hold it with one hand while clamping workpiece to angle plate with C-clamps (Figure 50)

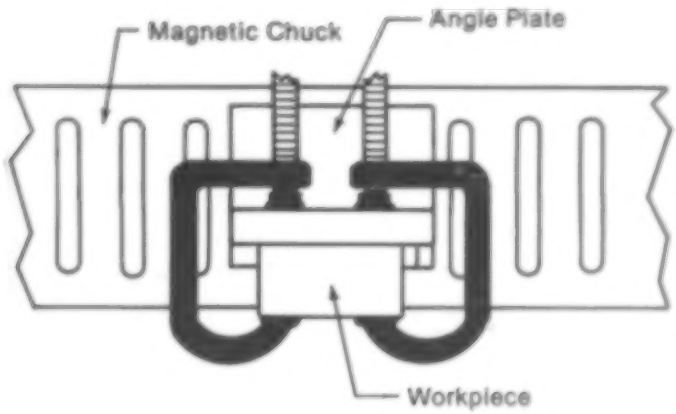
FIGURE 50



K. Place angle plate on grinding paper so that face of angle plate is parallel to table travel; energize magnetic chuck (Figure 51)

(NOTE: If desired, the adjustable parallel may be used when grinding.)

FIGURE 51



JOB SHEET #4

L. Adjust table reverse dogs so that wheel clears workpiece 1 inch at each end

M. Turn machine on, and adjust table travel to 25 inches per minute

N. Set cross-feed movement at 0.030 inch per cut; place power feeds in NEUTRAL position

O. Position workpiece under wheel so that 1/8 inch overlaps

P. Start grinder and turn on coolant

Q. Lower wheel slowly until it sparks workpiece

R. Engage fine feed; raise wheel about 0.005 inch

S. Hand feed wheel over surface of workpiece to check for high points, and then move wheel to back side of workpiece

T. Lower wheel 0.005 inch

U. Engage power feed; grind top surface

V. Move wheel to back side again, and lower wheel 0.001 inch

W. Make another cut; continue to make cuts until surface is smooth

X. Stop machine, and reposition table to clear setup from wheel

Y. Remove angle plate; remove workpiece from angle plate

Z. Clean chuck, and remove burrs from workpiece

AA. Place grinding paper on chuck, and place workpiece on paper with unground surface up

BB. Readjust reversing dogs if necessary, and grind surface flat

CC. Remove workpiece from chuck; measure width of workpiece between first two sides ground

DD. Measure width of workpiece between second two sides ground, and subtract the difference; mark the wider side

EE. Clean chuck, and place workpiece on clean grinding paper with one of narrower surfaces up

FF. Energize chuck, and use fine-feed adjustment to raise wheel a distance equal to the difference in the two widths of workpiece

JOB SHEET #4

GG. Position workpiece under wheel; move wheel down until it just sparks workpiece; grind off an amount equal to the difference in the two widths using cuts of 0.001 inch or less

HH. Remove workpiece, deburr, and turn in workpiece to instructor for evaluation

II. Clean machine and work area; put away all tools

SURFACE GRINDING
UNIT II

JOB SHEET #5 — GRIND AN ANGULAR SURFACE

I. Equipment and materials

A. Surface grinder with magnetic chuck and coolant

B. Sine bar, 5-inch

C. Angle plate, 4-inch

D. Gauge blocks (81-piece set)

E. Two C-clamps, 4-inch

F. Dial indicator and height gauge

G. Type #1 32A46-J8VBE or equivalent grinding wheel (mounted)

H. Single-point diamond mounted in holder

I. Dressing stick

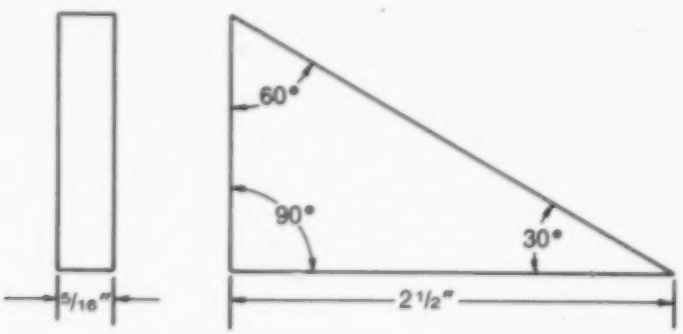
J. Hard oilstone

K. Medium oilstone

L. Clean cloth

M. Premachined material, heat-treated and tempered to 58 C ± 2 (Figure 52)

FIGURE 52



JOB SHEET #5

N. Surface plate

O. Steel rule, 12-inch

P. Sandpaper

Q. Soft-faced mallet

R. Grinding paper

II. Procedure

A. Dress grinding wheel

B. Clean chuck, and remove burrs with hard oilstone; wipe with hand to remove dirt

C. Clean scale from workpiece with sandpaper

D. Place one of the flat sides of workpiece down on chuck, energize chuck, and grind that side smooth

E. Remove workpiece from chuck and deburr; clean chuck

F. Place ground side of workpiece down; energize chuck

G. Grind second side smooth and parallel to first side

H. Remove workpiece from chuck and deburr; clean chuck

I. Place piece of grinding paper slightly larger than base of angle plate near center of chuck

J. Clean surface plate and angle plate

K. Place base of angle plate on surface plate

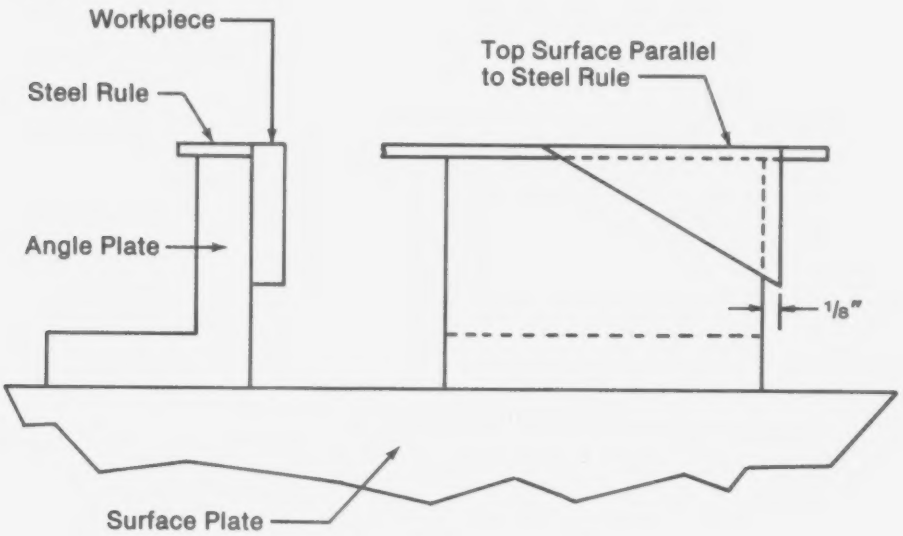
L. Mount test indicator in height gauge; clean base of height gauge and place on surface plate

M. Place steel rule on top surface of angle plate so that edge is even with length and face of angle plate

JOB SHEET #5

N. Place one side of ground angle on face of angle plate with long side of 90-degree angle up and even with steel rule, with short side of 90-degree angle 1/8 inch past edge of surface plate (Figure 53)

FIGURE 53



O. Clamp workpiece to angle plate with one clamp; remove steel rule

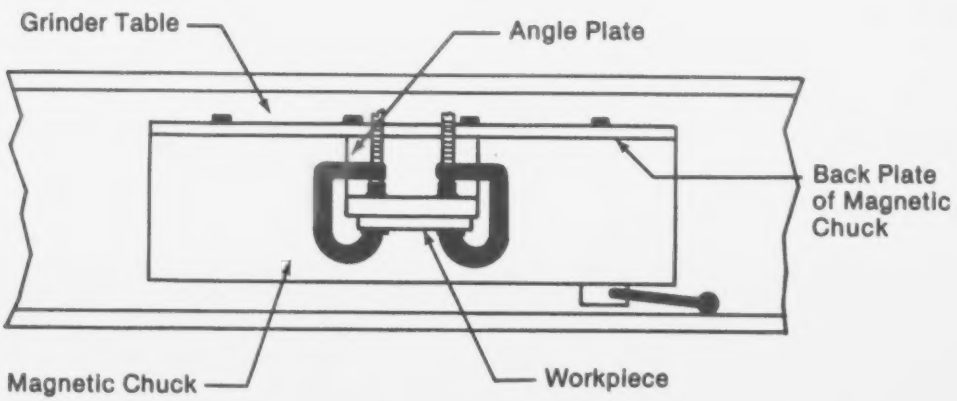
P. Use test indicator to check top surface of workpiece

(NOTE: It must be within 0.003 inch of parallel to top surface of surface plate; adjust with soft-faced mallet if necessary.)

Q. Place second clamp on workpiece and secure

R. Set angle plate on magnetic chuck with length parallel to table (Figure 54)

FIGURE 54



JOB SHEET #5

S. Grind top edge smooth and flat

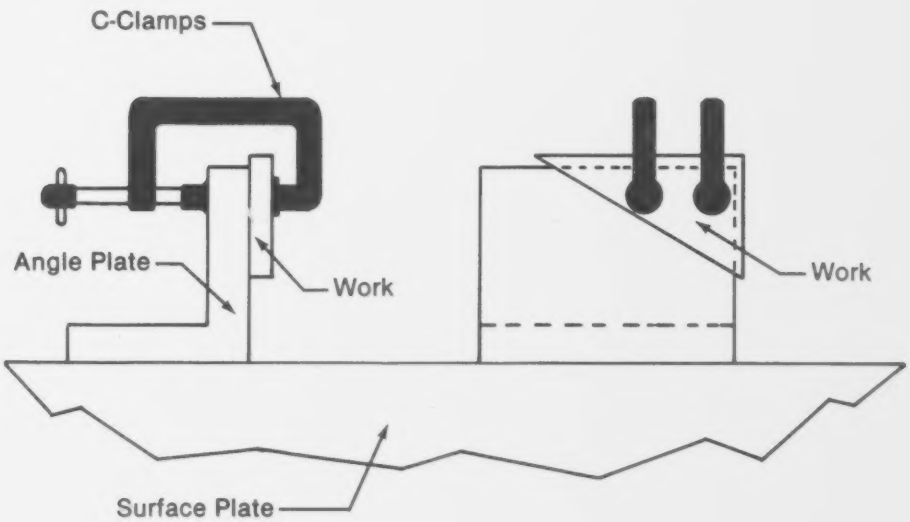
T. Remove angle plate from chuck; wipe grinding particles from it and the chuck

U. Place base of angle plate on surface plate

V. Reposition clamp near 30-degree angle of workpiece so that clamp frame is over surface just ground; retighten clamp, and then reposition other clamp frame over top surface just ground (Figure 55)

(NOTE: This position will allow the angle plate to be laid on its side to grind the other side of the 90-degree angle.)

FIGURE 55



W. Check ground surface with indicator

(NOTE: This surface should be within 0.0001 inch of parallel to surface plate at each end. Adjust if necessary.)

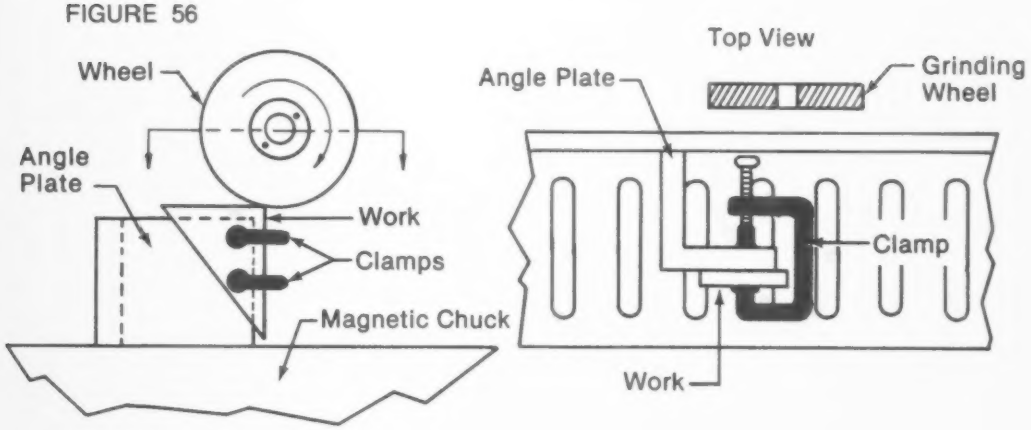
X. Place side of angle plate on chuck so that short side of 90-degree angle of workpiece is up

Y. Readjust and position grinding wheel

JOB SHEET #5

Z. Grind top surface smooth and flat (Figure 56)

FIGURE 56



AA. Remove angle plate from chuck; clean chuck

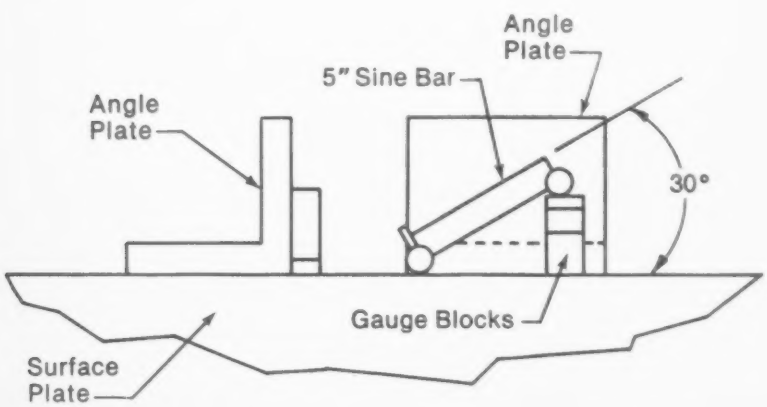
BB. Unclamp and deburr workpiece; clean angle plate

CC. Set base of angle plate on surface plate

DD. Set sine bar against angle plate, using gauge blocks to raise one end to 2.5 inches (Figure 57)

(NOTE: Sine-bar setting is determined by multiplying sine of angle times length of sine bar; in this case, 0.5 x 5 = 2.5 inches.)

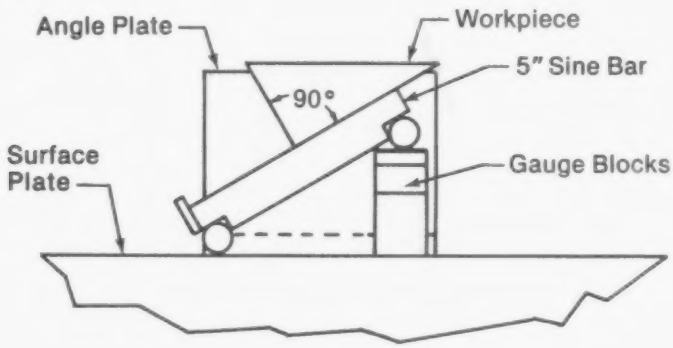
FIGURE 57



JOB SHEET #5

EE. Place workpiece on sine bar with long side of 90-degree angle on surface of sine bar and against angle plate, with unground surface 1/8 inch above top of angle plate (Figure 58)

FIGURE 58



FF. Place C-clamps on workpiece so that top surface can be ground; remove sine bar and gauge blocks

GG. Place angle plate on clean grinding paper in center of chuck; energize chuck

HH. Adjust wheel and grind surface smooth and flat

II. Remove angle plate from chuck, and remove workpiece from angle plate; clean angle plate

JJ. Hone sharp edges of workpiece, and turn in workpiece to instructor for evaluation

(NOTE: If magnetic sine chuck is available, ask your instructor to show you how it could have been used for this procedure.)

KK. Clean machine; put away all tools

SURFACE GRINDING
UNIT II

JOB SHEET #6 — GRIND AN ANGULAR SURFACE
USING CONNETIC V-BLOCK

I. Equipment and materials

A. Surface grinder with magnetic chuck and coolant

B. Connetic V-block, 2-inch

C. Type #1 32A46-H8VBE grinding wheel (mounted)

D. Single-point diamond mounted in holder

E. Dressing stick

F. Hard oilstone

G. Medium oilstone

H. Clean cloth

I. Grinding paper

J. Steel block, heat-treated and tempered to 58 C ± 2, premachined, 2″ × 2″ × 5″ with 1½-inch, 90-degree "V" centered along length of 2-inch side

K. Parallel, 1½″ × ½″ × 6″

L. Grease pencil

II. Procedure

A. Dress grinding wheel

B. Clean chuck, and remove burrs with hard oilstone; wipe with hands to remove any dirt

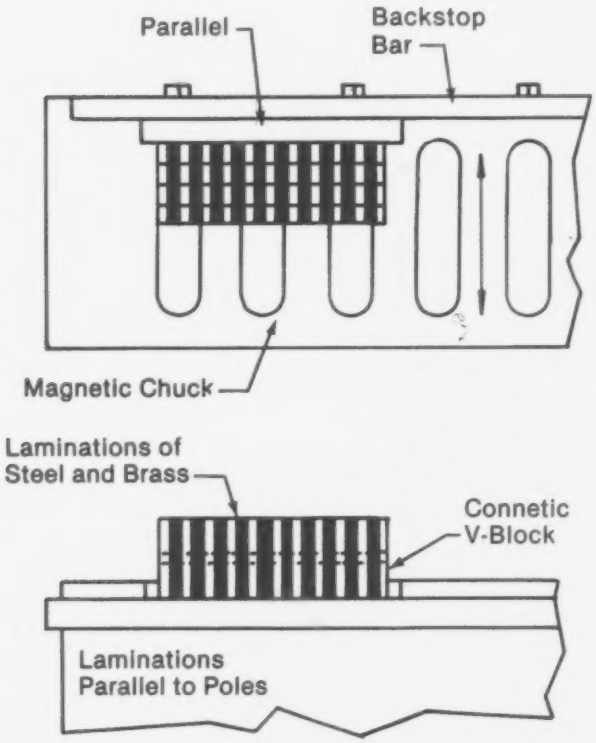
C. Check connetic V-block for burrs; remove if necessary and clean

D. Place grinding paper slightly larger than V-block in center of magnetic chuck 1⅜ inches from backstop

JOB SHEET #6

E. Place parallel against backstop, and set connetic V-block against parallel on grinding paper (Figure 59)

FIGURE 59



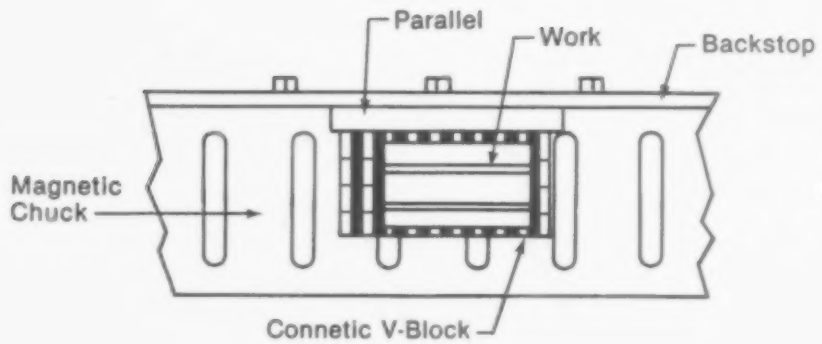
JOB SHEET #6

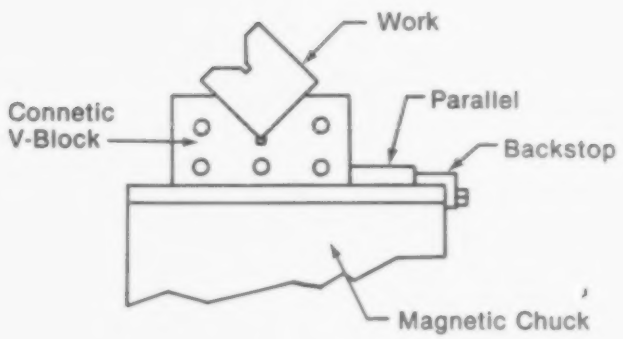
F. Set workpiece in V-block with premachined angle up and opposite backstop; energize chuck and check workpiece to see that it is held securely (Figure 60)

(NOTE: Connetic V-blocks and parallels should be used for light grinding only.)

(CAUTION: Workpiece held in or on connetic blocks must have sides of contact ground to provide maximum holding power.)

FIGURE 60





JOB SHEET #6

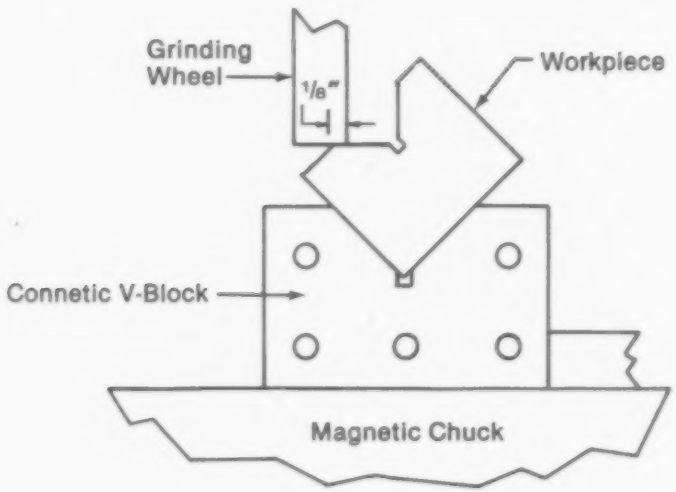
G. Position grinding wheel over surface of machined angle, which is parallel to table, and set table stops

H. Lower wheel until it is about 1/16 inch from surface to be ground

I. Crank cross feed until 1/8 inch of back side of wheel is over surface to be ground; carefully lower wheel until it sparks; mark fine-feed adjustment knob with grease pencil (Figure 61)

(CAUTION: If wheel strikes workpiece too hard, the wheel pressure will pull workpiece loose, causing damage to workpiece, connetic block, or grinding wheel, and possibly injuring the operator.)

FIGURE 61



J. Engage fine-feed adjustment knob to raise wheel 0.003 inch

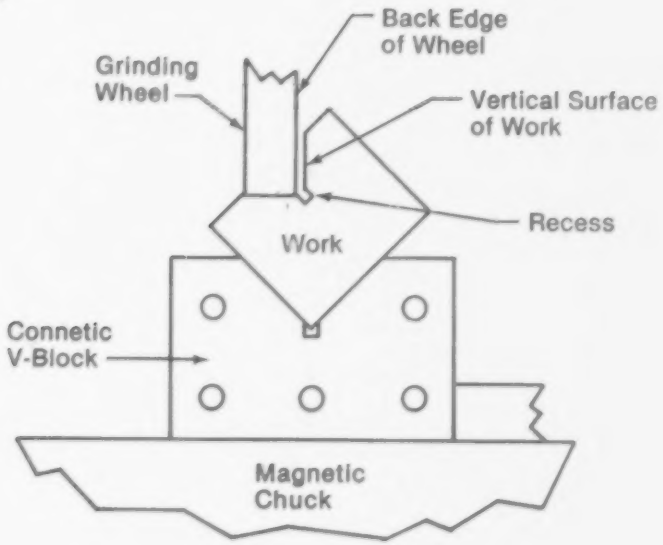
K. Turn table handwheel to move workpiece from stop to stop; at same time turn cross-feed handwheel clockwise until back edge of wheel reaches recess

JOB SHEET #6

L. With grease pencil mark cross-feed dial at reading (Figure 62)

(CAUTION: Do not strike the vertical portion of the workpiece with the back side of the grinding wheel. The pressure may pull the workpiece from the connetic V-block.)

FIGURE 62



M. Use cross feed to move wheel clear of workpiece; lower wheel 0.0005 inch with fine-feed adjustment knob

N. Engage power table feed, and turn cross-feed handwheel to feed wheel about 0.015 inch per stroke until cross feed reaches line marked on cross-feed dial

(NOTE: The amount of cross feed may be more than one revolution of the handwheel.)

O. Repeat step M until surface is smooth and flat

P. Mark dial setting of elevating handwheel when workpiece is smooth and flat

Q. Move wheel to clear front edge of workpiece

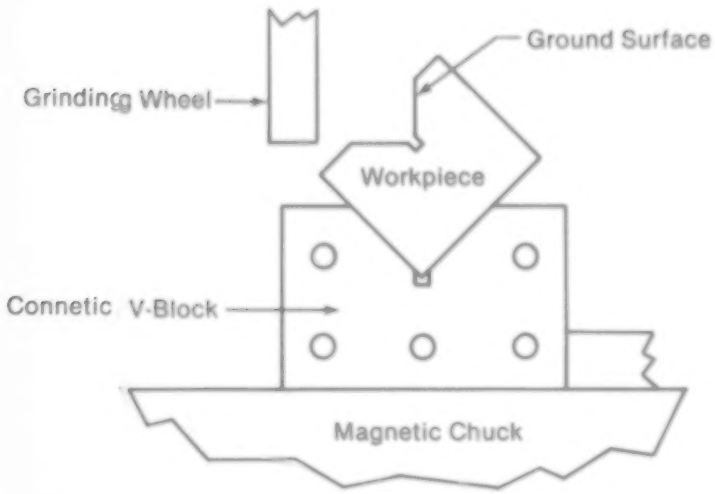
R. Raise wheel by turning fine-feed adjustment knob about 0.005 inch above original starting position

S. Deenergize chuck

JOB SHEET #6

T. Remowe workpiece and turn it so that surface just ground is in vertical position (Figure 63)

FIGURE 63



U. Energizze magnetic chuck

V. Repeatt steps I through R to finish this surface to the same setting as first side

(NOTE:: If surface is not smooth and flat at this setting, continue to grind until surface is flat and smooth. Mark that setting, and regrind the first surface to the same setting.)

W. Stop grrinder

X. Removve workpiece from V-block; hone edges of surfaces just ground

Y. Clean machine; put away all tools

Z. Turn in workpiece to instructor for evaluation

(NOTE:: Discuss with your instructor the use of a magnetic V-block in this procedure.)

SURFACE GRINDING
UNIT II

JOB SHEET #7 — GRIND A VERTICAL SURFACE

I. Equipment and materials

A. Surface grinder with magnetic chuck and coolant

B. Type #12 AA46-J8V40 grinding wheel

C. Single-point diamond mounted in holder

D. Dressing stick

E. Hard oilstone

F. Medium oilstone

G. Clean cloth

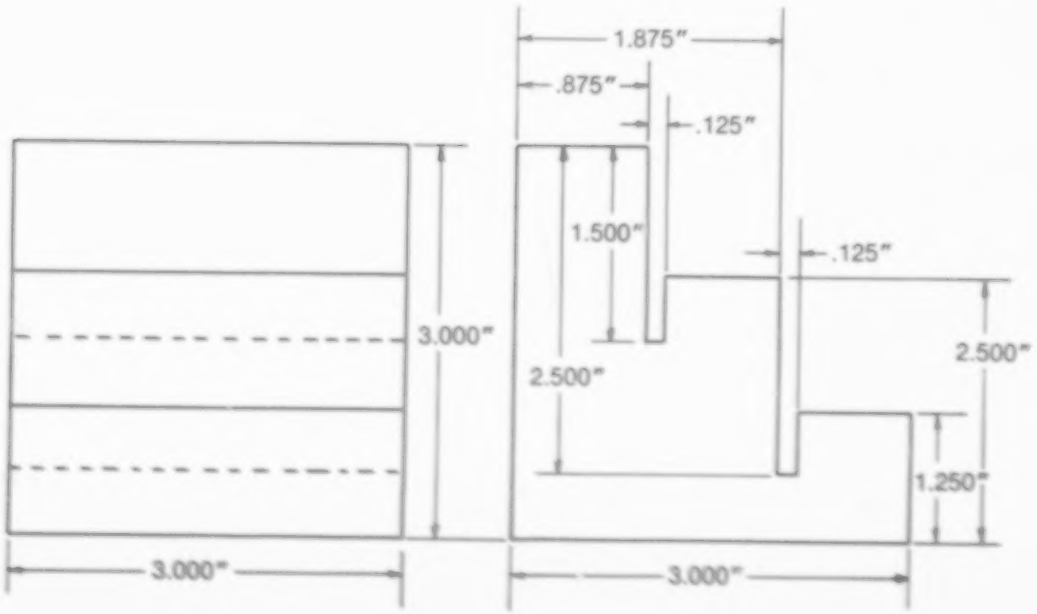
H. Grinding paper

I. Dial test indicator with holder and swivel

J. Soft-faced mallet

K. Steel workpiece, SAE 4140, premachined, hardened, tempered, and heat-treated to 58 C ± 2 (Figure 64)

FIGURE 64



JOB SHEET #7

II. Procedure

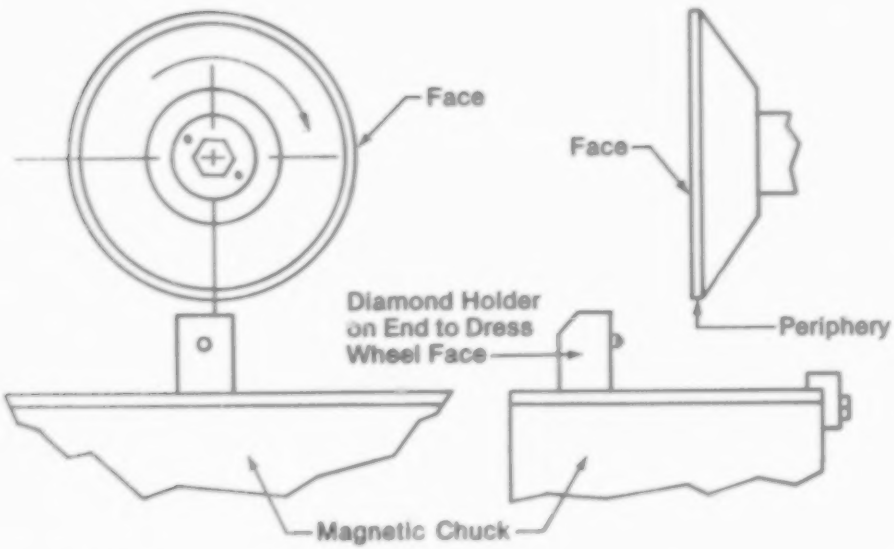
(NOTE: Grinding vertical surfaces is not as common as grinding horizontal surfaces. It is necessary to grind a vertical surface if the position of the workpiece cannot be moved or the size or shape will not permit grinding with the periphery of the wheel.)

A. Mount grinding wheel

B. Dress periphery of wheel so that it is true and has a flat surface of about 1/8 inch

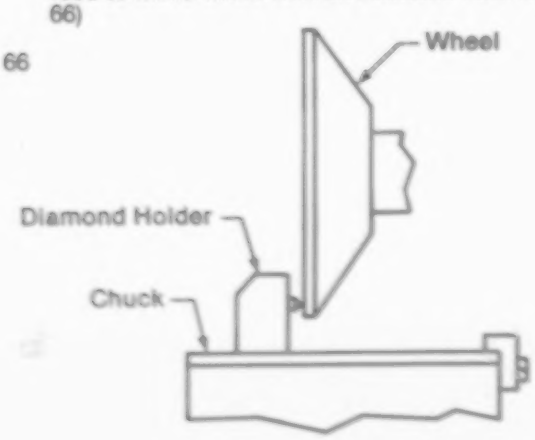
1. Stand dresser on end slightly left of center of chuck so that diamond points toward wheel; energize chuck (Figure 65)

FIGURE 65



2. Lower the wheel until its face is at height of diamond; crank cross feed to move wheel toward diamond until it just starts to cut (Figure 66)

FIGURE 66



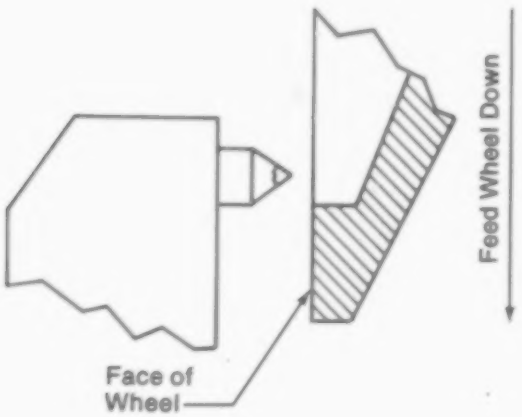
JOB SHEET #7

3. Raise wheel with elevating handwheel until wheel is above point of diamond

4. Move wheel 0.001 inch toward diamond by turning fine-feed adjustment knob of cross feed

5. Lower wheel until diamond is past flat surface of wheel face (Figure 67)

FIGURE 67

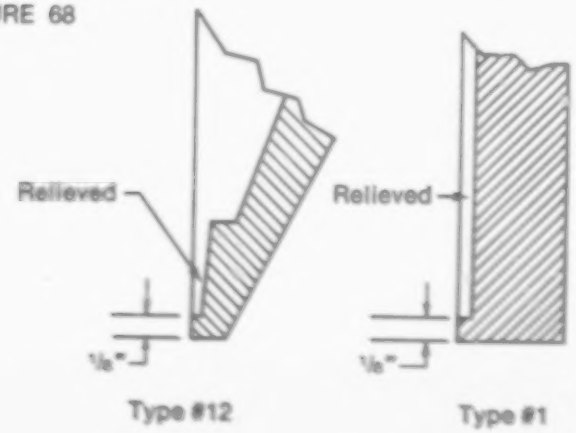


6. Continue to dress wheel by making 0.001-inch cuts until face of wheel is smooth and straight

C. Use dressing stick to relieve face of wheel about 1/32 inch deep from the inside out, leaving 1/8-inch periphery; dress sharp corner formed between face and periphery (Figure 68)

(NOTE: The side of a Type #1 wheel can be dressed and relieved to perform a vertical grinding operation; however, it is not recommended if a Type #12 wheel is available.)

FIGURE 68



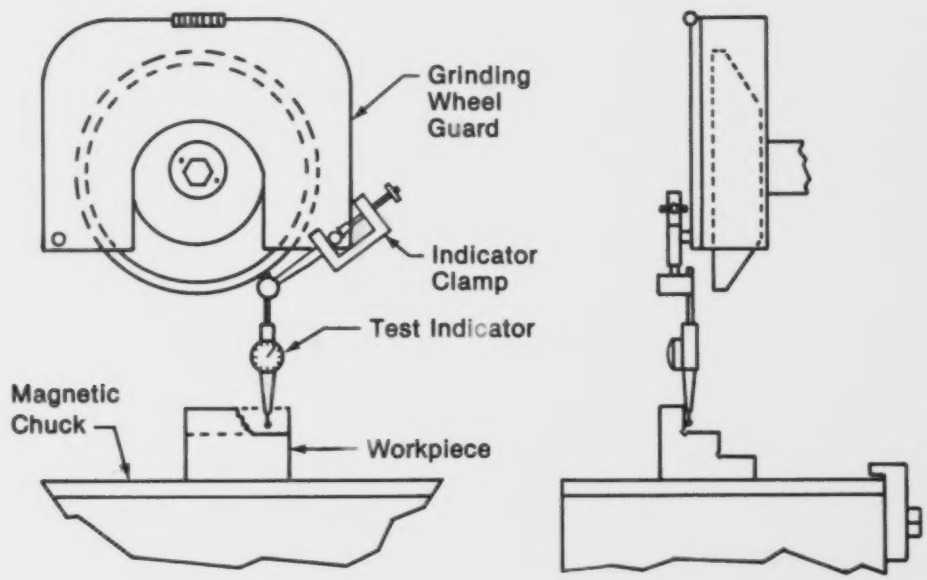
JOB SHEET #7

D. Place piece of grinding paper slightly longer than workpiece near center of chuck; place workpiece on chuck with machined surfaces facing relieved portion of grinding wheel and parallel to table

E. Energize chuck just enough to hold workpiece

F. Align vertical surface of workpiece with dial indicator clamped to grinding-wheel guard so that surface is within 0.001 inch of true; fully energize chuck (Figure 69)

FIGURE 69



G. Recheck alignment of workpiece; remove and store indicator

H. Adjust table dogs so that wheel clears workpiece right and left; set table to slow speed

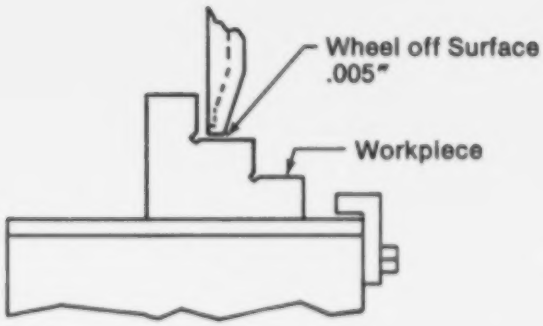
I. Start grinding wheel, and adjust coolant flow

J. Position wheel so that periphery is over horizontal surface of workpiece; carefully lower wheel to horizontal surface until it just sparks

JOB SHEET #7

K. Raise wheel about 0.005 inch (Figure 70)

FIGURE 70



L. Carefully feed wheel to vertical surface until wheel sparks; set fine-feed adjustment knob for cross feed

M. Turn fine-feed adjustment knob 0.0005 inch, moving wheel into vertical surface

N. Continue to grind until surface is rough ground

O. Stop table clear of workpiece

P. Redress face slightly with dressing stick

Q. Start table moving; finish grinding vertical surface with feeds of 0.0001 to 0.0002 inch by turning cross-feed fine-feed adjustment knob

(NOTE: Because the wheel face was dressed, it may take several feeds of 0.0001 inch before the wheel makes its first cut. Nevertheless, continue fine feeds until the wheel begins to cut.)

R. Grind vertical surface until a smooth surface finish is obtained

S. Repeat steps J through R until all surfaces have been ground

T. Stop table clear of workpiece

U. Disengage fine feed, and crank wheel away from workpiece

V. Turn off coolant, and allow wheel to run for one minute

W. Remove workpiece from chuck

X. Hone sharp edges of workpiece

Y. Clean grinder; put away all tools

Z. Turn in workpiece to instructor for evaluation

SURFACE GRINDING
UNIT II

JOB SHEET #8 — GRIND A WORKPIECE TO DIMENSION

I. Equipment and materials

A. Surface grinder with magnetic chuck and coolant

B. Type #1 32A46-J8VBE grinding wheel

C. Single-point diamond mounted in holder

D. Dressing stick

E. Hard oilstone

F. Medium oilstone

G. Clean cloth

H. Grinding paper

I. Depth micrometer set, 0- to 3-inch

J. Steel block, premachined and hardened

(NOTE: This is the material used in Job Sheet #7.)

K. Parallel, ½" x 1½" x 6"

II. Procedure

A. Mount grinding wheel

B. Dress periphery of wheel, and clean magnetic chuck

C. Check for burrs; remove with stone, and reclean chuck if necessary

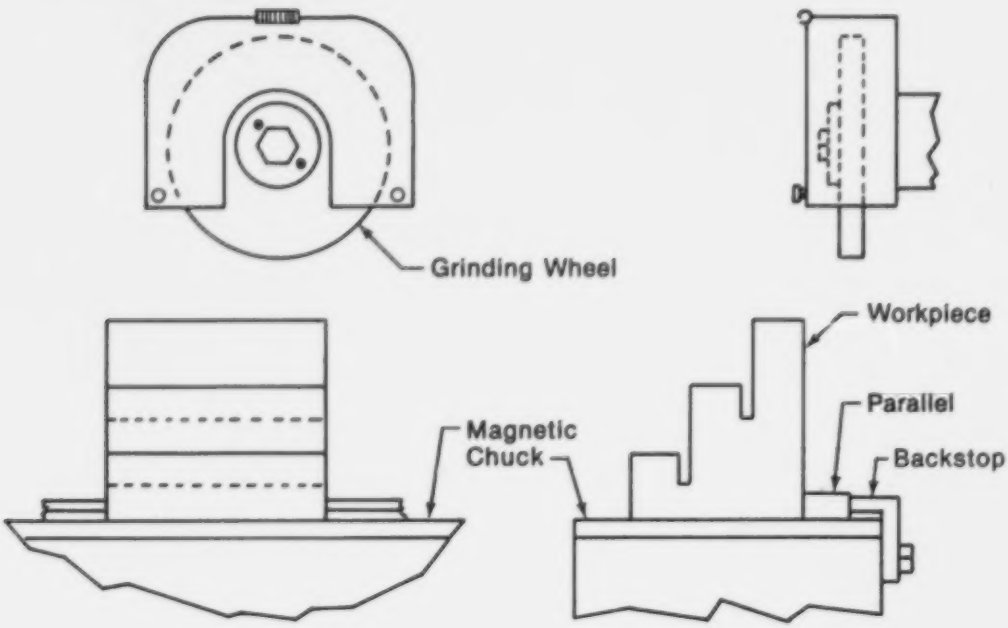
D. Place a piece of grinding paper slightly larger than workpiece base near center of chuck

E. Set parallel against backstop

JOB SHEET #8

F. Place workpiece on paper and slide it against parallel so that steps of workpiece face you (Figure 71)

FIGURE 71



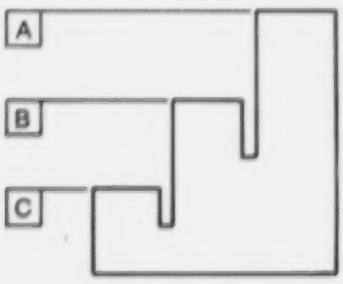
G. Energize chuck

H. Set right and left table dogs so that wheel clears workpiece about 1 inch at each end

I. Adjust table speed to 60 inches per minute

J. Measure distance from surface A to surface B and record that distance; measure from surface B to surface C and record that measurement (Figure 72)

FIGURE 72

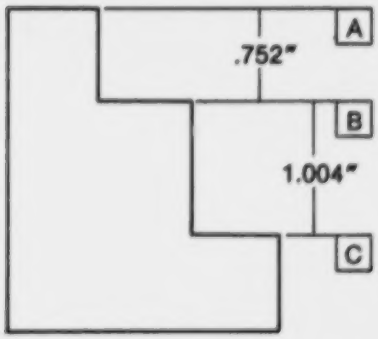


JOB SHEET #8

K. Determine surface(s) to be ground

1. If distance from surface A to surface B is greater than 0.750 inch, and distance from surface B to surface C is greater than 1.000 inch, grind the amount of the larger difference from surface A and the amount of the smaller difference from surface B (Figure 73).

FIGURE 73



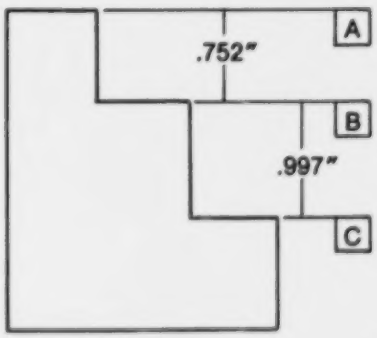
A to B
0.752
- 0.750
0.002

B to C
1.004
- 1.000
0.004

Total Difference = 0.006 inch

2. If the distance from surface A to surface B is greater than 0.750 inch, and the distance from surface B to surface C is less than 1.000 inch, grind the distance greater than 0.750 inch from surface A, and then grind surface C (Figure 74).

FIGURE 74



A to B
0.752
- 0.750
0.002

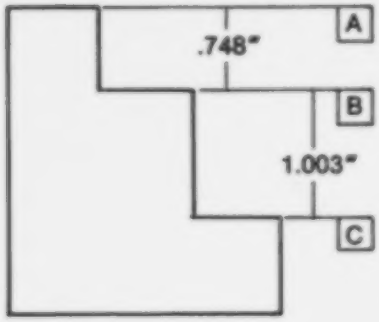
B to C
1.000
- 0.997
0.003

Grind 0.002 inch from surface A and then grind 0.003 from surface C.

JOB SHEET #8

3. If the distance from surface A to surface B is less than 0.750 inch, and the distance from surface B to surface C is greater than 1.000 inch, grind the amount of the greater difference from surface B, and then grind either surface A or surface C to get correct dimension (Figure 75).

FIGURE 75



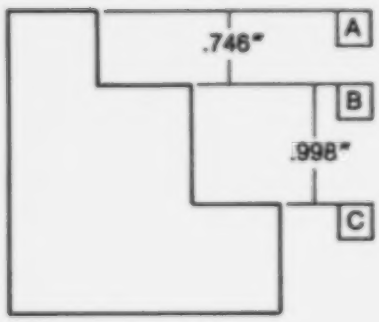
A to B
0.750
- 0.748
0.002

B to C
1.003
- 1.000
0.003

0.002 inch must be ground from surface B and 0.002 inch ground from surface A.

4. If the distance from surface A to surface B is less than 0.750 inch, and the distance from surface B is less than 1.000 inch, grind surface B to 0.750 inch from surface A, and then grind surface C to 1.000 inch from surface B to surface C (Figure 76)

FIGURE 76



A to B
0.750
- 0.746
0.004

B to C
1.000
- 0.998
0.002

0.004 inch must be ground from surface B, then grind 0.006 inch from surface C.

JOB SHEET #8

L. Grind the required surface(s) to produce a distance of 0.750 inch ± 0.001 inch between surfaces A and B and a distance of 1.000 inch ± 0.001 inch between surfaces C and D

M. Measure workpiece, and repeat steps K through L as required

N. Remove workpiece from chuck; hone edges

O. Clean machine; put away all tools

P. Turn in workpiece to instructor for evaluation

SURFACE GRINDING
UNIT II

JOB SHEET #9 — DRESS A GRINDING WHEEL TO A 90-DEGREE INCLUDED ANGLE

I. Equipment and materials

A. Surface grinder with magnetic chuck and coolant

B. Type #1 32A46-J8VBE grinding wheel (mounted)

C. Micrometer, 2- to 3-inch

D. Radius and tangent wheel dresser with diamond

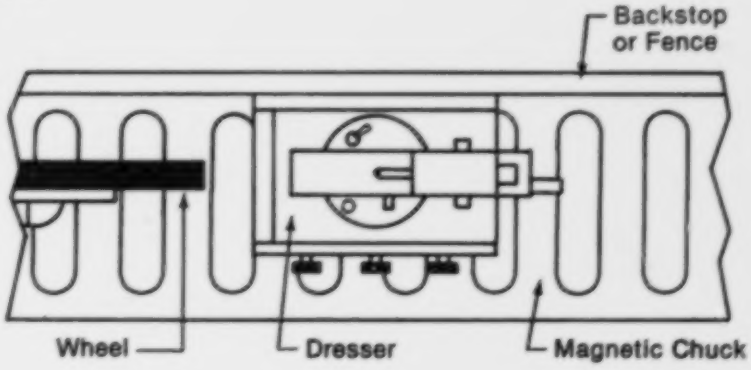
E. Clean cloth

II. Procedure

A. Clean magnetic chuck

B. Clean base of dresser and place it on chuck so that base is parallel to chuck (Figure 77)

FIGURE 77



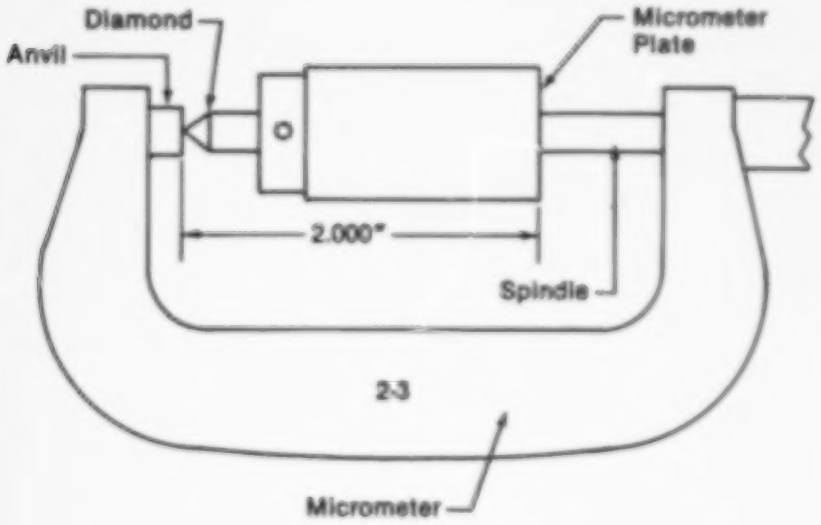
C. Energize chuck

D. Place diamond in holder

JOB SHEET #9

E. Set micrometer at 2.000 inches; place micrometer over dresser, upright with micrometer spindle against dresser micrometer plate; slide the diamond out until it contacts micrometer anvil (Figure 78)

FIGURE 78

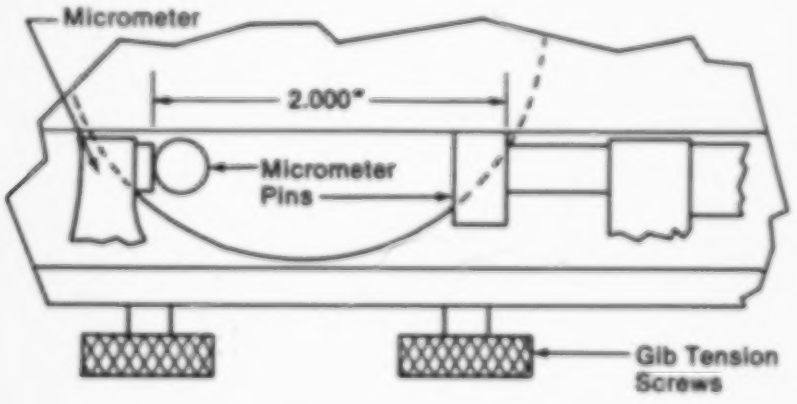


F. Tighten diamond retaining screw and check setting

G. Loosen slide lock, and adjust micrometer pins to 2.000 inches(Figure 79)

(NOTE: With the micrometer pins set at the same distance as that from the micrometer plate to the diamond point, the dresser is set at a zero radius, and the diamond point will stay on center when the swivel base is rotated.)

FIGURE 79



JOB SHEET #9

H. Tighten slide lock, and loosen swivel-ring locking screw

I. Set upright to zero position, and bring both swivel-ring stop pins to zero position against fixed stop

J. Hold swivel-ring stop pins against stop; rotate swivel base clockwise until vernier reading for lower pin is on 45° 0′

(NOTE: The lower pin will lock itself on this setting and maintain it while the upper pin is set.)

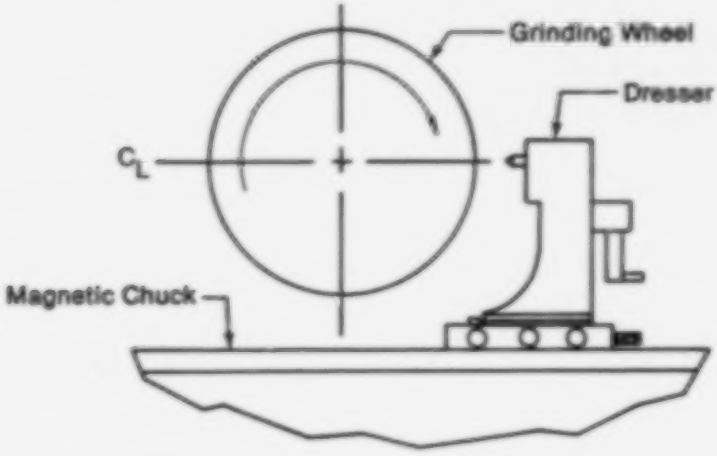
K. Swivel dresser upright in opposite direction until vernier reading for upper pin is on 45° 0′; tighten swivel-ring locking screw

L. Check settings by swiveling upright to the right until stop pin makes contact with fixed stop; then swivel upright to the left until stop pin makes contact with fixed stop

(NOTE: Readings in both positions should be 45° 0′. If either reading is not on 45° 0′, the fine adjustment screws on the fixed stop must be adjusted.)

M. Lower wheel until diamond is on center height (Figure 80)

FIGURE 80

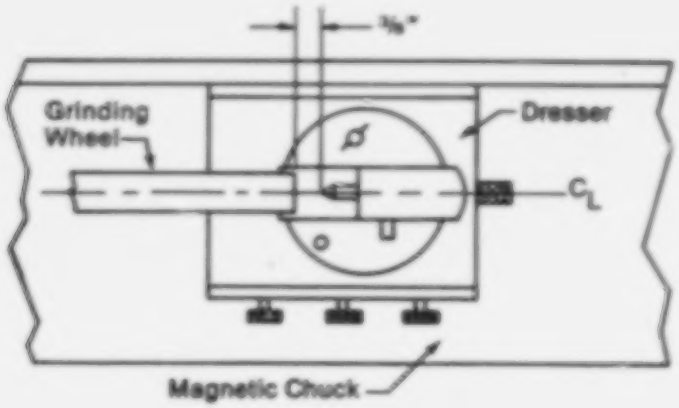


JOB SHEET #9

N. Position diamond in near center of wheel width, about ⅛ inch from wheel surface (Figure 81)

(NOTE: Depending on the wheel-guard design, it may be necessary to turn or remove the guard to dress a wheel.)

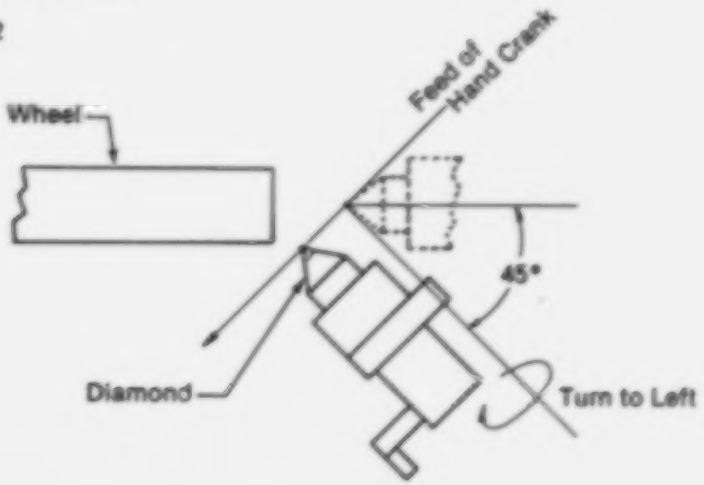
FIGURE 81



O. Start grinder

P. Swivel upright clockwise until stop pin is at fixed stop; then move angle traverse control handle so that point of diamond is near front edge of grinding wheel (Figure 82)

FIGURE 82



JOB SHEET #9

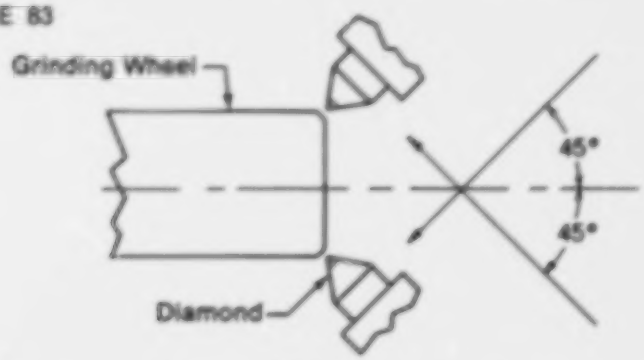
Q. Turn micrometer base lead-screw knob to move slide forward until diamond just touches edge of wheel

R. Return angle traverse control handle to center; swivel upright to zero position

S. Advance micrometer base 0.002 inch, using micrometer base lead-screw knob

T. Move swivel left and cut angle; move swivel right and cut angle (Figure 83)

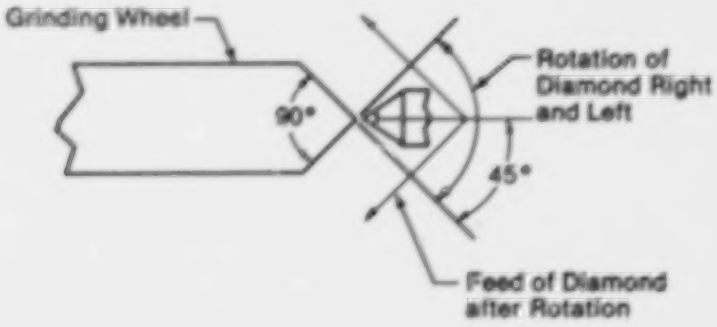
FIGURE 83



U. Continue to take cuts of 0.002 inch until wheel is dressed to a V-shape, forming a 90-degree angle (Figure 84)

(NOTE: To dress the wheel more quickly, use a dressing stick to rough shape wheel. Then, use the dresser to finish shaping the wheel.)

FIGURE 84



JOB SHEET #9

V. Move table so that dresser is clear of wheel; stop grinder

W. Remove dresser from chuck; clean and store dresser

X. Clean machine; put away all tools

Y. Have instructor inspect dressed wheel

(CAUTION: If wheel guard was removed, replace it before leaving machine.)

SURFACE GRINDING
UNIT II

JOB SHEET #10 — DRESS A GRINDING WHEEL HAVING A 1/8-INCH RADIUS AND 30- AND 40-DEGREE ANGLES TANGENT TO RADIUS

(NOTE: These procedures may need to be modified for the dresser being used.)

I. Equipment and materials

A. Surface grinder with magnetic chuck and coolant

B. Type #1 32A46-J8VBE 1/2- to 5/8-inch-wide grinding wheel (mounted)

C. Micrometer, 1- to 2-inch

D. Radius and tangent wheel dresser with diamond

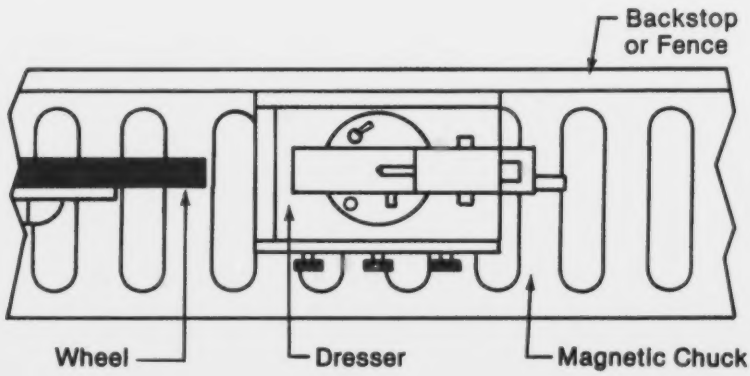
E. Clean cloth

II. Procedure

A. Clean magnetic chuck

B. Clean base of dresser and place on chuck so that base is parallel to chuck (Figure 85)

FIGURE 85



JOB SHEET #10

C. Energize chuck

D. Place diamond in holder

E. Set micrometer at 2.000 inches; place micrometer over dresser, upright with micrometer spindle against dresser micrometer plate; slide diamond out until it contacts micrometer anvil

F. Tighten diamond retaining screw

G. Determine micrometer pin setting

1. Measure distance from diamond to micrometer plate

2. Subtract amount of radius required

EXAMPLE: A diamond measurement of 1.995 inches minus the radius of 0.125 inch would equal 1.870 inches for the micrometer pin setting.

H. Loosen slide lock, and adjust micrometer pins to required setting; tighten slide lock

I. Loosen swivel-ring locking screw, and rotate the swivel rings clockwise to a setting of 30 degrees

J. Rotate upright counterclockwise to a setting of 40 degrees; tighten swivel-ring locking screw

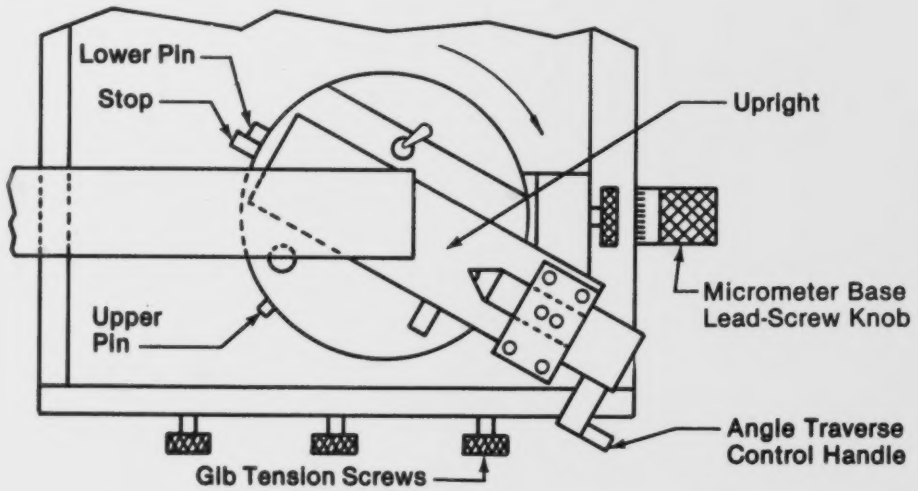
K. Position diamond at center height on wheel, with diamond near center of wheel width, about 3/8 inch from face of wheel

L. Start grinder

M. Swivel upright clockwise until stop makes contact with lower pin

N. Turn angle traverse control handle clockwise until diamond is near edge of wheel (Figure 86)

FIGURE 86



JOB SHEET #10

O. Move table longitudinally until diamond is about 1/32 inch from edge of wheel

P. Loosen gib tension screws, and turn micrometer base lead-screw knob until diamond just cuts wheel

Q. Return angle traverse control handle to lower position; rotate upright counterclockwise to upper stop pin

R. Turn angle traverse control handle counterclockwise slowly until diamond has cleared back edge of wheel

S. Advance micrometer base 0.002 inch, using micrometer base lead-screw knob

T. Crank angle traverse control handle clockwise to center position

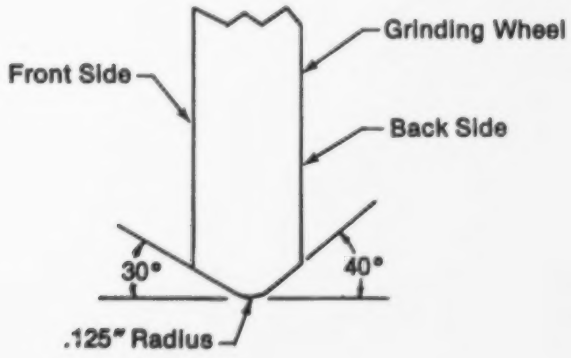
U. Rotate swivel to lower pin; turn angle traverse control handle clockwise until diamond clears edge of wheel at front side

V. Advance micrometer base another 0.002 inch

W. Traverse back and generate radius; repeat for angle on back side

X. Continue to dress wheel until diamond cuts the 0.125-inch radius with a 30-degree angle on front side of wheel and a 40-degree angle on back side (Figure 87)

FIGURE 87



Convex Shape on Wheel to Produce a Concave Shape in Workpiece

SURFACE GRINDING
UNIT II

TEST

NAME _____ SCORE _____

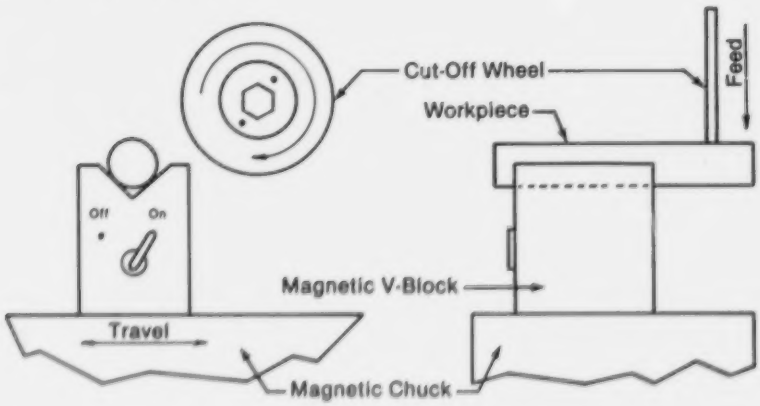
1. Match terms associated with surface grinding to their correct definitions. Write the correct numbers in the blanks.

_____a.	To apply power to a magnetic device	1. Traverse
_____b.	Outward-curving surface	2. Reciprocating
_____c.	Movement of grinding wheel from back to front during grinding operation	3. Across
_____d.	Degree of difficulty involved in grinding a material	4. Surface finish
_____e.	Horizontal movement of the table right and left	5. Scale
_____f.	Internal strain in workpiece produced by manufacturing, machining, or heat-treating	6. Dress
_____g.	To shape grinding wheel flat, or to a specific form, and to expose new, sharp cutting particles	7. Concave
_____h.	Moving alternately back and forth	8. Fishtails
_____i.	Inward-curving surface	9. Flat
_____j.	Carbon and other impurities on the surface of steel that has been heat-treated or hot-rolled	10. Stress
_____k.	Appearance or degree of smoothness of workpiece	11. Grindability
_____l.	To remove burrs by rubbing surface of magnetic chuck with hard oilstone	12. Convex
_____m.	Surface that is straight and free of warps or bows	13. Energize
_____n.	Random scratches on workpiece surface	14. Stone the chuck

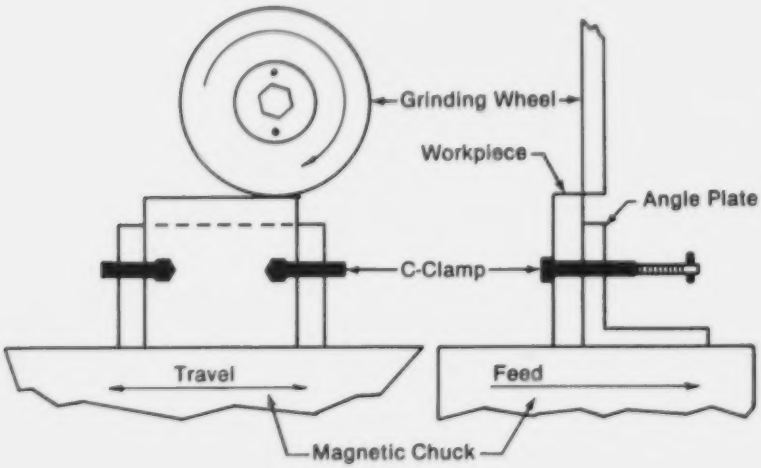
TEST

2. Identify surface grinding operations. Write the number of the correct grinding operation in the blank. Some blanks may contain more than one number. Some numbers may be used more than once.

1. Grinding vertical surfaces
2. Grinding angular surfaces
3. Grinding grooves or slots
4. Grinding flat surfaces
5. Grinding edges
6. Cutting off
7. Form or profile grinding

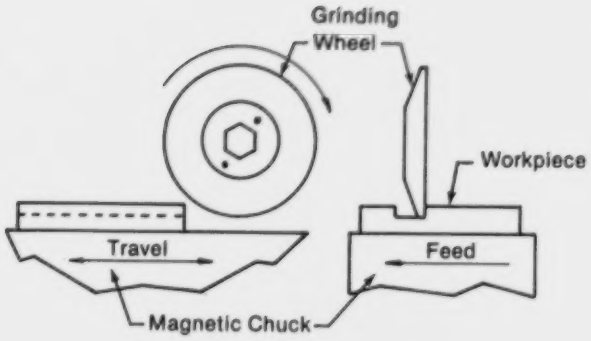


_____a.

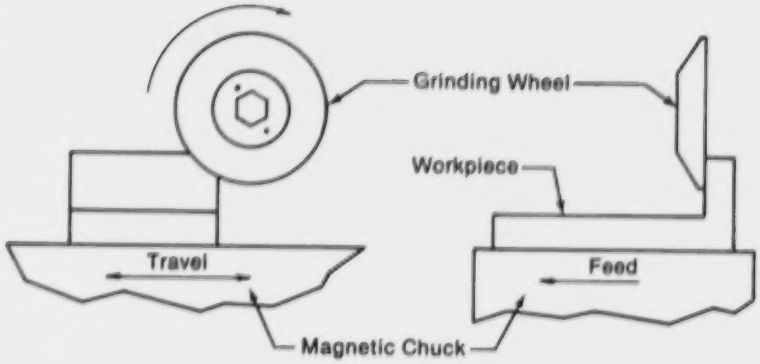


_____b.

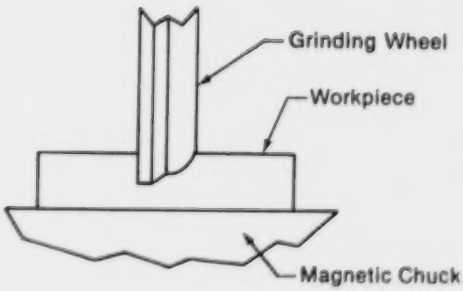
TEST


Grinding
Wheel
Workpiece
Travel
Feed
Magnetic Chuck

_____c.

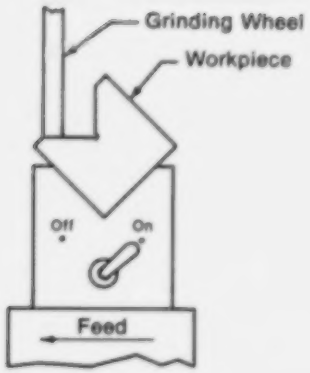

Grinding Wheel
Workpiece
Travel
Feed
Magnetic Chuck

_____d.

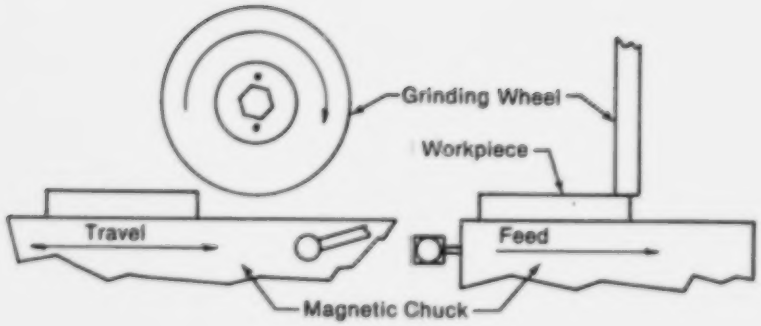

Grinding Wheel
Workpiece
Magnetic Chuck

_____e.

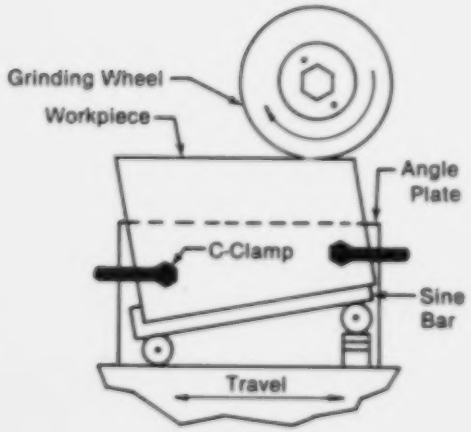
TEST


Grinding Wheel
Workpiece
Off
On
Feed

_____f.

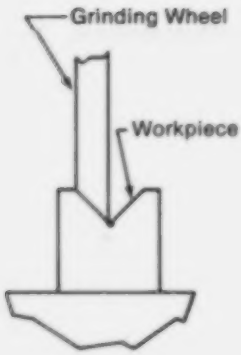

Grinding Wheel
Workpiece
Travel
Feed
Magnetic Chuck

_____g.

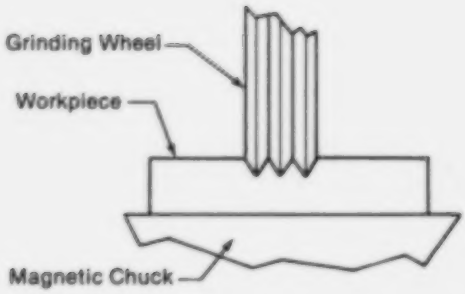

Grinding Wheel
Workpiece
Angle Plate
C-Clamp
Sine Bar
Travel

_____h.

TEST



_____i.



_____j.

3. Identify types of grinding wheels used for specific surface grinding operations. Write the correct type number(s) in the blanks. Some blanks may contain more than one answer. Some answers may be used more than once.

_____a.	Grinding flat surfaces	Type #1 (straight wheel)
_____b.	Grinding edges	Type #5 (recessed one side)
_____c.	Grinding angular surfaces	Type #12 (dish)
_____d.	Form grinding	
_____e.	Grinding vertical surfaces	
_____f.	Grinding grooves or slots	

TEST

4. Select proper grinding-wheel composition for different materials. Write the correct numbers in the blanks. Some blanks may contain more than one answer. Some answers may be used more than once.

_____a.	High speed steel	1. Aluminum oxide with vitrified bond
_____b.	Hardened steel	2. Cubic boron nitride with resinoid bond
_____c.	Carbide	3. Silicon carbide with vitrified bond
_____d.	Cast iron (soft), bronze, and aluminum	4. Diamond with metal bond
_____e.	Soft steel	

5. Match types of grinding-wheel dressers to their correct functions/descriptions. Write the correct numbers in the blanks. Functions/descriptions continue on the following page.

_____a.	Primarily used for form or contour dressing; shape of plate dresses grinding wheel; dressers of this type are usually mounted so that dressing can occur during grinding operation	1. Single-point mounted diamond held in holder
_____b.	Form dresses wheel by using a diamond to generate a set radius for a concave or convex surface	2. Single-point mounted diamond held in overhead-type dresser
_____c.	Holder is mounted directly to magnetic chuck; dresses periphery of grinding wheel flat	3. Dressing stick
_____d.	Mounted to chuck or table; used to rough dress grinding wheels concentric to spindle prior to flat dressing	4. Brake-controlled dressing and truing device
_____e.	Hand-held dresser used to remove ragged edges from grinding wheel; also used for rough forming or shaping	5. Diamond-plate dressing block
_____f.	Mounts to magnetic chuck; is adjusted to desired angle; dressing of wheel may be done mechanically or by hand using a diamond mounted in holder	6. Sine dresser (angle dresser)
_____g.	Permanently mounted to wheel guard; dresses periphery of grinding wheel flat	7. Radius dresser
		8. Radius and tangent dresser
		9. Pantograph or template-type dresser
		10. Roll dresser

TEST

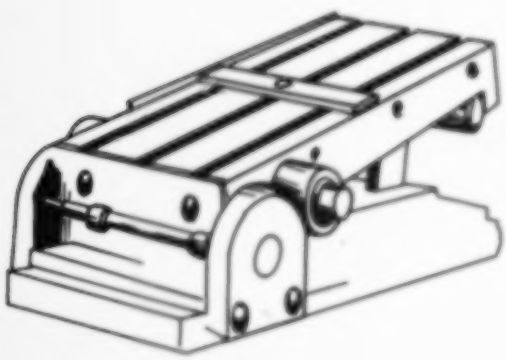
_____h. Form dresses wheel by using a mechanical finger that follows a template and generates shape of template

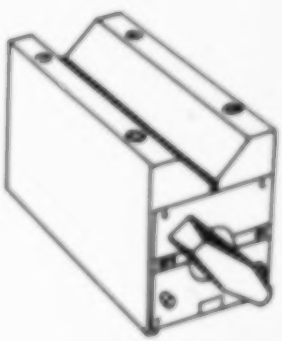
_____i. Mounted dresser used to dress and true grinding wheel; can be used to true diamond wheels when used with proper dressing stone

_____j. Form dresses wheel by using a diamond to generate angles, radii, or a combination of an angle and radius

6. Identify work-holding devices. Write the correct names in the blanks below each illustration.

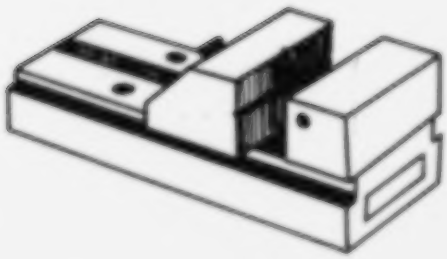
Magnetic chucks
Compound sine chuck
Angle plate
Vise (precision)
V-block and clamp
Vacuum chuck
Connetic V-block
Magnetic V-block
Sine vise
Magna-vise clamps
Adapter plate
Adjustable angle plate
Collet block chucks
Indexing collet fixture
Connetic parallels



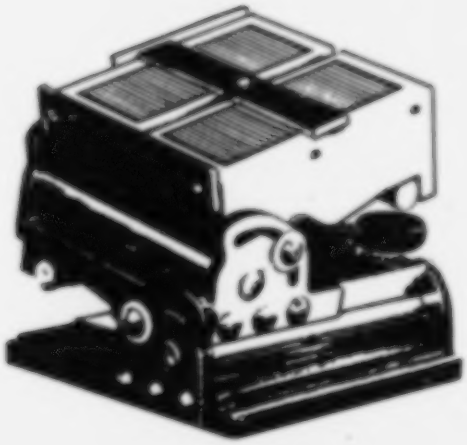


a. _____ b. _____

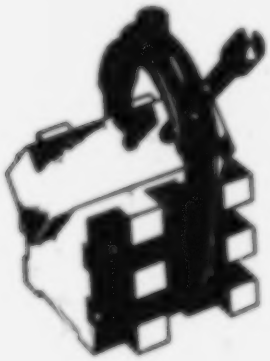
TEST



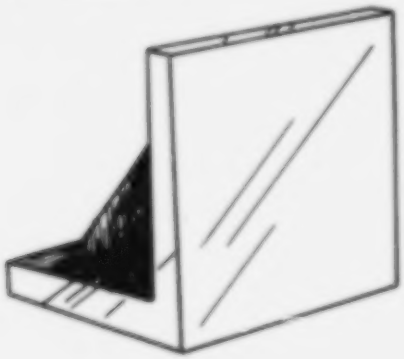
c. _____



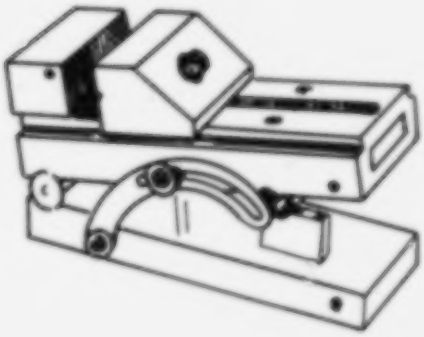
d. _____



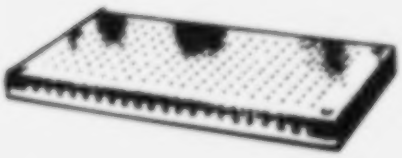
e. _____



f. _____

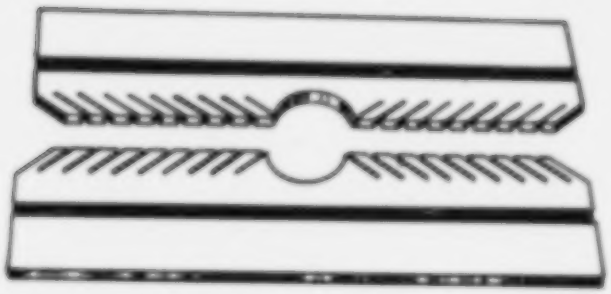


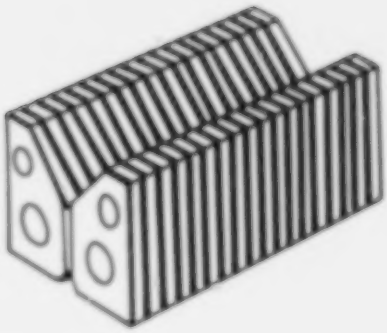
g. _____



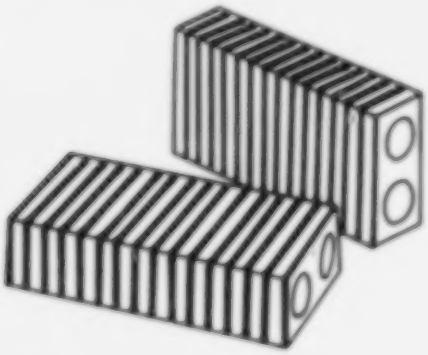
h. _____

TEST





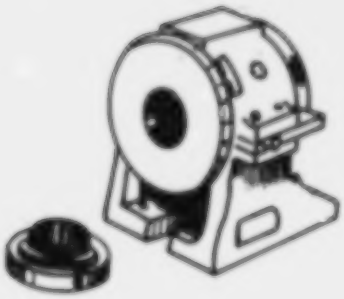
i. _____ j. _____



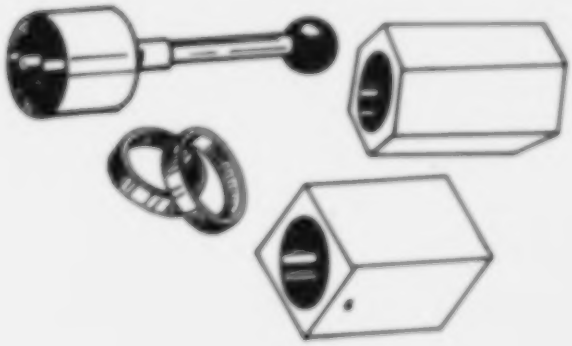
k. _____

l. _____

TEST



m. _____ n. _____



o. _____

TEST

7. Match the parts of a radius and tangent dresser to their correct uses. Write the correct numbers in the blanks.

_____a.	Stop swivel-base and ring rotation at setting of fixed stop	1. Diamond
_____b.	Indicates amount of movement of swivel ring	2. Micrometer plate
_____c.	Locks slide in place at setting of micrometer pins	3. Angle traverse control handle
_____d.	Calibrates diamond to swivel base	4. Swivel-ring locking screw
_____e.	Set radius limits	5. Micrometer base lead-screw knob
_____f.	Moves diamond in a straight line at angle desired	6. Gib tension screws
_____g.	Supports diamond and micrometer plate	7. Swivel ring
_____h.	Used with swivel ring to set amount of radius	8. Swivel-ring stop pins
_____i.	Supports swivel-base slide and upright	9. Micrometer pins
_____j.	Supports swivel base; allows horizontal movement of swivel base	10. Base
_____k.	Cuts wheel to shape	11. Swivel-base slide
_____l.	Allows swivel ring to be set to generate a radius up to 180 degrees	12. Swivel base
_____m.	Lock swivel-base slide in base	13. Traverse lock
_____n.	Rotates on swivel base to set amount of radius	14. Fixed stop
_____o.	Moves swivel-base slide with micrometer accuracy; calibrated in 0.001-inch increments	15. Vernier plate
_____p.	Prevents movement of angle traverse control handle	16. Slide lock
_____q.	Stops rotation of upright by making contact with swivel-ring stop pins	17. Upright

TEST

8. Select from the following list probable causes of surface grinding problems. For each possible cause, write an "X" in the box under the appropriate problem listed. More than one box may be marked for each cause.

Cause	Problem			
	Chatter	Burning or Checking	Scratches	Concave or Convex Areas on Workpiece
a. Wheel not dressed or improperly dressed				
b. Coolant applied improperly				
c. Coolant dirty				
d. Wheel too soft				
e. Wheel too hard				
f. Wheel too coarse				
g. Wheel out of round				
h. Wheel out of balance				
i. Wheel too fine				
j. Excessive feed				
k. Excessive depth of cut				
l. Internal machine vibrations				
m. Chuck dirty or burred				
n. Loose dirt under guard				
o. Workpiece not held securely				
p. Table feed too slow				
q. Workpiece too thin				
r. External machine vibrations				
s. Spindle bearings bad				
t. Heat-treatment stress				

TEST

9. State safety rules that apply to magnetic chuck work.

(NOTE: The required score on this portion of the test is 100 percent.)

a. Cleaning — _____

_____

b. Deburring — _____

_____

c. Workpiece — _____

_____

d. Paper — _____

_____

e. Magnetized strips — _____

_____

f. Small parts — _____

_____

g. Jewelry — _____

_____

h. Setup — _____

_____

i. Eyes — _____

_____

j. Connetic V-blocks and parallels — _____

_____

_____

TEST

k. Magna-vise clamps — _____

_____

l. Side and end plates — _____

_____

m. Resurfacing — _____

_____

(NOTE: Test question 10 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

10. Demonstrate the ability to

a. Remove and replace a grinding wheel.

b. Dress a wheel flat.

c. Grind a workpiece flat and parallel.

d. Grind a workpiece square.

e. Grind an angular surface.

f. Grind an angular surface using connetic V-block.

g. Grind a vertical surface.

h. Grind a workpiece to dimension.

i. Dress a grinding wheel to a 90-degree included angle.

j. Dress a grinding wheel having a 1/8-inch radius and 30- and 40-degree angles tangent to radius.

SURFACE GRINDING
UNIT II

ANSWERS TO TEST

1.	a.	13	h.	2
	b.	12	i.	7
	c.	3	j.	5
	d.	11	k.	4
	e.	1	l.	14
	f.	10	m.	9
	g.	6	n.	8

2.	a.	6	f.	2, 4
	b.	5	g.	4
	c.	1, 3	h.	2
	d.	1	i.	2, 7
	e.	7	j.	7

3.	a.	#1, #5, #12
	b.	#1, #5
	c.	#1, #5
	d.	#1, #5
	e.	#12
	f.	#1, #12

4.	a.	1, 2
	b.	1
	c.	3, 4
	d.	3
	e.	1

ANSWERS TO TEST

5.

a.	5	f.	6	
b.	7	g.	2	
c.	1	h.	9	
d.	10	i.	4	
e.	3	j.	8	

6.

a. Adjustable angle plate
b. Magnetic V-block
c. Vise (precision)
d. Compound sine chuck
e. V-block and clamp
f. Angle plate
g. Sine vise
h. Vacuum chuck
i. Magna-vise clamps
j. Connetic V-block
k. Connetic parallels
l. Magnetic chucks
m. Adapter plate
n. Indexing collet fixture
o. Collet block chucks

7.

a.	8	g.	17	m.	6
b.	15	h.	12	n.	7
c.	16	i.	10	o.	5
d.	2	j.	11	p.	13
e.	9	k.	1	q.	14
f.	3	l.	4		

ANSWERS TO TEST

8.

	Chatter	Burning or Checking	Scratches	Concave or Convex Areas on Workpiece
a.		X	X	X
b.		X		X
c.			X	
d.	X		X	
e.	X	X		X
f.			X	
g.	X			
h.	X			
i.		X		
j.		X		
k.		X		
l.	X			
m.			X	X
n.			X	
o.			X	
p.				X
q.				X
r.	X			
s.	X			
t.				X

ANSWERS TO TEST

9. a. Clean top surface of chuck before placing anything on chuck

   b. Rub top surface of chuck with a hard, fine oilstone to remove nicks and burrs

   c. Carefully place workpiece on chuck to avoid nicking, burring, or scratching the chucking surface; never chuck workpiece that has burrs

   d. Use thin grinding paper between workpiece and chuck surface

   e. If possible, touch three magnetized strips to workpiece for sufficient holding power

   f. Block small parts with steel bars or parallels to prevent work from slipping

   g. Never wear jewelry while using magnetic chuck

   h. Before grinding always check setup to make sure that workpiece is firmly held

   i. Wear approved eye protection when operating grinder

   j. Position laminated setup tools with laminations parallel to inner poles of magnetic chuck so that holding power is transferred to workpiece

   k. Check workpiece to ensure that it is held securely

   l. Remove before resurfacing magnetic chuck

   m. Always regrind chuck surface with chuck energized, using cuts of no more than 0.001 inch per pass

10. Performance skills evaluated to the satisfaction of the instructor

CYLINDRICAL GRINDING
UNIT III

UNIT OBJECTIVE

After completing this unit, the student should be able to set up and operate the cylindrical grinder; mount, balance, and dress a grinding wheel; grind work between centers; and regulate wheel speed, work speed, and rate of table travel. The student will show this knowledge by completing assignment sheets, job sheets, and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with cylindrical grinding to their correct definitions.
2. Identify cylindrical grinding operations.
3. Arrange in order procedures for removing and replacing a grinding wheel.
4. Arrange in order steps for dressing wheel for cylindrical grinding.
5. Name types of wheel dressers.
6. Identify accessories used with cylindrical grinders.
7. Match accessories used with cylindrical grinders to their correct functions.
8. Select from a list probable causes of grinding problems.
9. Determine work rotation with respect to wheel rotation.
10. Calculate wheel speed (rpm), work speed, and rate of table travel (ipm).
11. Demonstrate the ability to
    a. Remove and replace a grinding wheel.
    b. Use table-mounted holder to dress a grinding wheel.
    c. Grind a workpiece straight and to size.
    d. Grind a workpiece to dimension.
    e. Grind a #4 Morse taper.
    f. Grind an internal surface.
    g. Grind an angular surface.

CYLINDRICAL GRINDING
UNIT III

SUGGESTED ACTIVITIES

I. Suggested activities

A. Personalize assignment sheet and job sheet procedures.

(NOTE: Any job can be done a number of ways. Procedures outlined for assignment sheets and job sheets are not meant to be considered as the *only* way or the *recommended* way of performing the jobs; they are meant to be considered as a method of instruction in performing the various jobs.)

B. Make transparencies.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheets.

F. Discuss information and assignment sheets.

G. Provide students with job sheets.

H. Relate information, assignment, and job sheets to industrial practices.

I. Tour plant involved in grinding production work so that students can see grinders used by industry.

J. Show samples of ground workpieces.

K. Demonstrate and discuss procedures outlined in job sheets.

(NOTE: You may need to make changes in job sheet procedures to fit your particular machine.)

L. Discuss safety, and emphasize specific safety that must be observed when setting table dogs.

M. Give test.

N. Reteach and retest if necessary.

II. Instructional materials

A. Objective sheet

B. Suggested activities

C. Information sheet

SUGGESTED ACTIVITIES

D. Transparency masters

1. TM #1 — Types of Wheel Dressers
2. TM #2 — Types of Wheel Dressers (Continued)
3. TM #3 — Accessories Used with Cylindrical Grinders
4. TM #4 — Accessories Used with Cylindrical Grinders (Continued)

E. Assignment sheets

1. Assignment Sheet #1 — Identify Cylindrical Grinding Operations
2. Assignment Sheet #2 — Calculate Wheel Speed (rpm), Work Speed, and Rate of Table Travel (ipm)
3. Assignment Sheet #3 — Plan Procedures for Grinding a Tapered Mandrel
4. Assignment Sheet #4 — Plan Procedures for Grinding a Lathe Center

F. Answers to assignment sheets

G. Job sheets

1. Job Sheet #1 — Remove and Replace a Grinding Wheel
2. Job Sheet #2 — Use Table-Mounted Holder to Dress a Grinding Wheel
3. Job Sheet #3 — Grind a Workpiece Straight and to Size
4. Job Sheet #4 — Grind a Workpiece to Dimension
5. Job Sheet #5 — Grind a #4 Morse Taper
6. Job Sheet #6 — Grind an Internal Surface
7. Job Sheet #7 — Grind an Angular Surface

H. Test

I. Answers to test

III. Unit references

A. Kibbe, Richard R., et al. *Machine Tool Practices.* New York: John Wiley and Sons, Inc., 1979.

B. Krar, S. F., and J. W. Oswald. *Grinding Technology.* Albany, New York: Delmar Publishers, 1974.

SUGGESTED ACTIVITIES

C. Krar, S. F., J. W. Oswald, and J. E. St. Amand. *Technology of Machine Tools.* Toronto: McGraw-Hill of Canada, Ltd., 1969.

D. Olivo, C. Thomas. *Fundamentals of Machine Technology.* Belmont, California: Burton Publishing/Division of Wadsworth, Inc., 1981.

E. *Operation and Maintenance of #1 Universal Grinding Machine, #21-99990-5.* North Kingstown, Rhode Island: Brown and Sharpe Company, 1965.

CYLINDRICAL GRINDING
UNIT III

INFORMATION SHEET

I. Terms and definitions

A. Work rotation — Rotation of workpiece at desired rate in opposite direction of grinding wheel

B. Work speed — Number of revolutions per minute (rpm) that workpiece should turn to give correct surface speed and to obtain maximum wheel life, chip removal, and desired finish

C. Work feed — Rate at which wheel is fed into workpiece each time table reverses

(NOTE: Machines with automatic feeds can be set to feed right, left, or both right and left.)

D. Wheel speed (rpm) — Number of revolutions per minute (rpm) that grinding wheel turns

(CAUTION: The wheel speed should not exceed that of the manufacturer's marking.)

(NOTE: Wheel should turn as close as possible to recommended maximum speed. As wheel wears, speed should be increased if possible.)

E. Automatic feed — Movement of table or workhead by hydraulic and/or mechanical feed

F. Live center — Center that revolves with workpiece

G. Dead center — Center that does not revolve

H. OD (outside diameter) grinding — Grinding on outside circumference of round workpiece

I. ID (inside diameter) grinding — Grinding on inside of workpiece to enlarge a bore or hole

J. Plain cylindrical grinder — Cylindrical grinder with headstock and workhead that are fixed; used to perform OD, straight, and taper grinding

K. Universal cylindrical grinder — Cylindrical grinder with headstock and workhead that can be swiveled; used to perform OD, ID, and face grinding

L. Internal cylindrical grinder — Cylindrical grinder designed especially for ID grinding

M. Dwell or tarry time — Pause at one or both ends of table travel to permit grinding wheel to grind workpiece to size and to provide for completion of feed before table reverses direction

N. Feed index — Mechanical feed device that allows for adjustment of feed depth

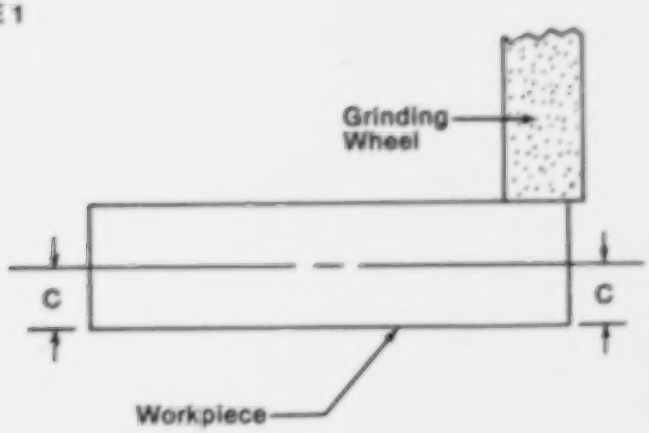
INFORMATION SHEET

II. Cylindrical grinding operations (Assignment Sheets #1, #3, and #4)

A. Straight grinding — Grinding a cylindrical surface to an accurate size and finish, with sides parallel to center axis throughout its length (Figure 1)

EXAMPLE:

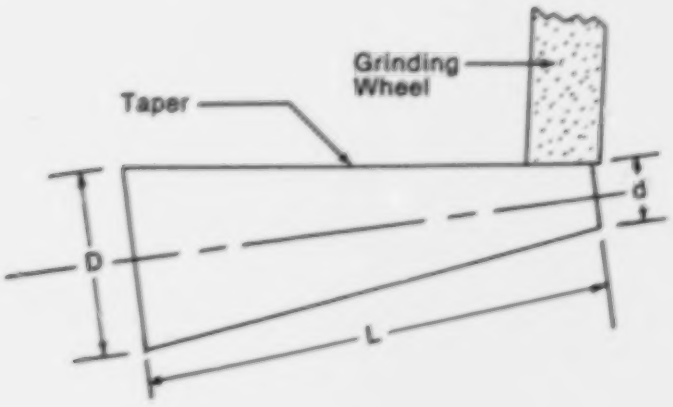
FIGURE 1



B. Taper grinding — Grinding a conical surface that changes in diameter at a constant rate along its axis (Figure 2)

EXAMPLE:

FIGURE 2



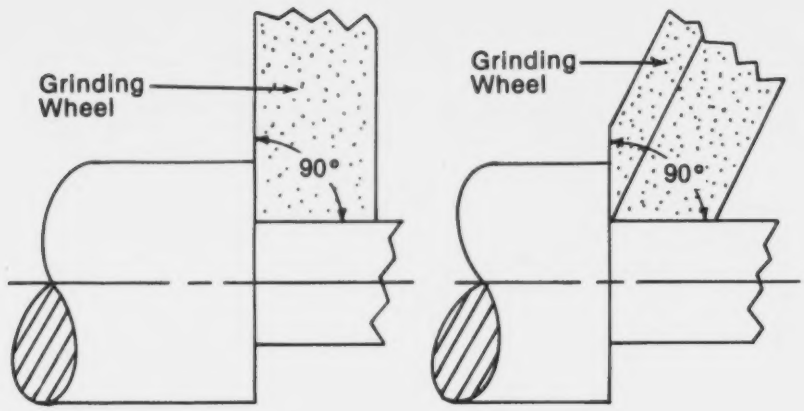
INFORMATION SHEET

C. Shoulder grinding — Grinding a surface 90 degrees to axis of workpiece (Figures 3 and 4)

(NOTE: Shoulders can be ground with the side of the wheel or by turning wheel head and dressing a 90-degree angle on the wheel. Shoulders that are deeper than one-half the width of the wheel can be ground by cross feeding.)

EXAMPLES:

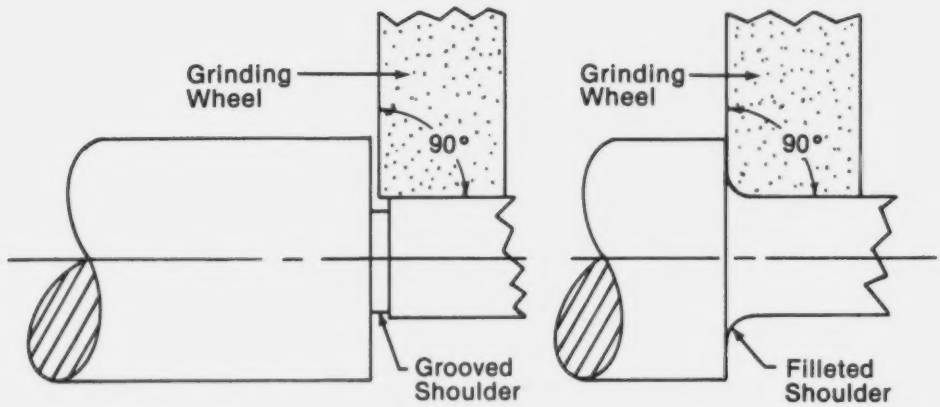
FIGURE 3



Side of Wheel Trued

Wheel Turned and Dressed to 90-Degree Angle

FIGURE 4



Side of Wheel Trued

Side of Wheel Dressed to Radius

INFORMATION SHEET

D. Contour (form) grinding — Grinding a surface to a particular shape by means of a grinding wheel dressed to produce the desired shape (Figures 5 and 6)

EXAMPLES:

FIGURE 5

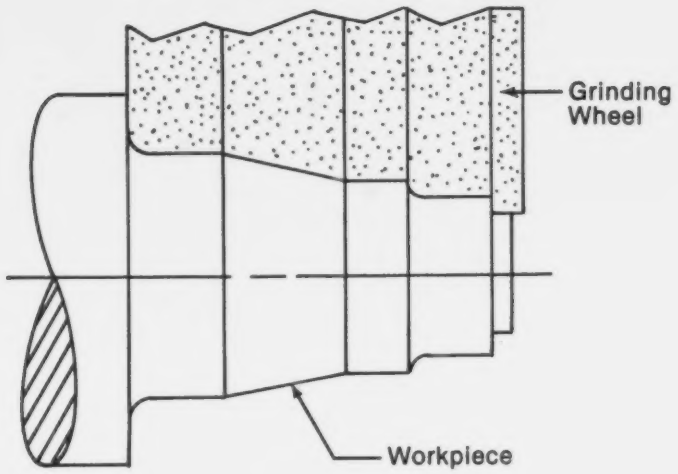
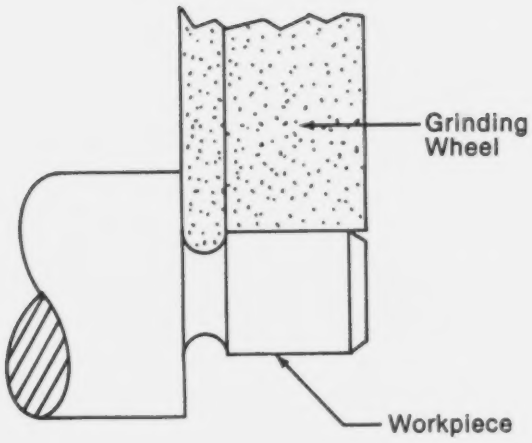


FIGURE 6



INFORMATION SHEET

E. Internal grinding — Grinding a hole or bore to an accurate size, taper, or finish (Figures 7 and 8)

(NOTE: Internal grinding is performed on an internal grinding machine, universal grinding machine with internal grinding spindle, or a tool-post grinder mounted to the compound of an engine lathe.)

EXAMPLES:

FIGURE 7

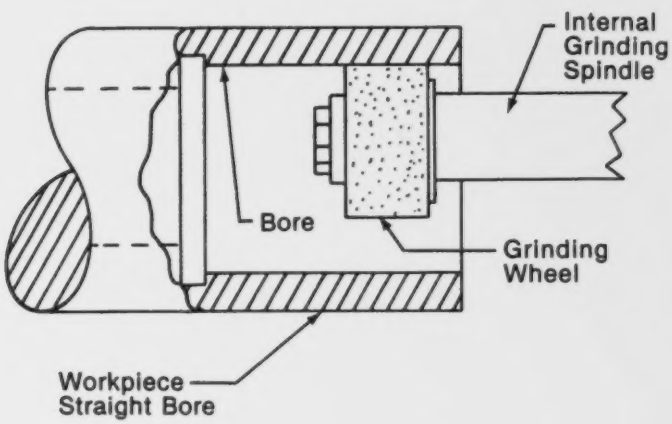
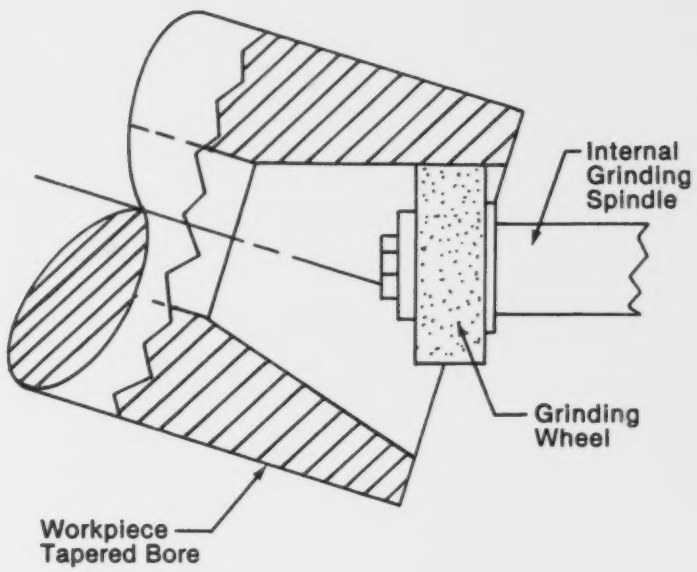


FIGURE 8



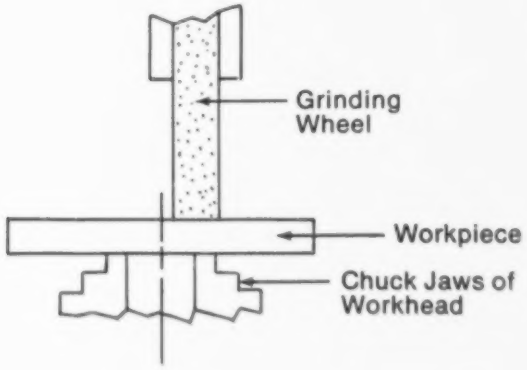
INFORMATION SHEET

F. Face grinding — Grinding end of workpiece by rotating surface to be ground at a 90-degree angle to grinding wheel (Figure 9)

(NOTE: Slight angles for purpose of relief can be face ground by setting the headstock at angles slightly less than 90 degrees.)

EXAMPLE:

FIGURE 9

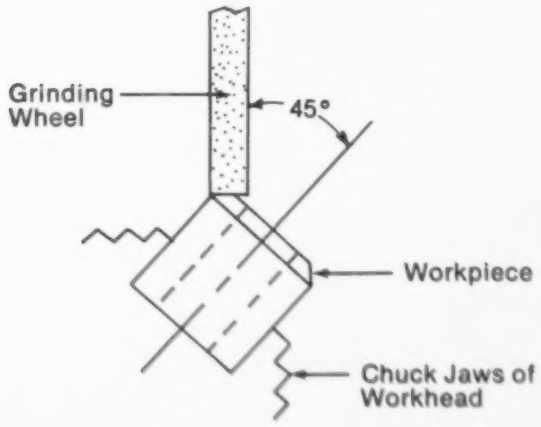


G. Angular grinding — Grinding an angle by rotating workhead at desired angle to grinding wheel (Figure 10)

(NOTE: This operation is usually done on a universal-type grinding machine.)

EXAMPLE:

FIGURE 10



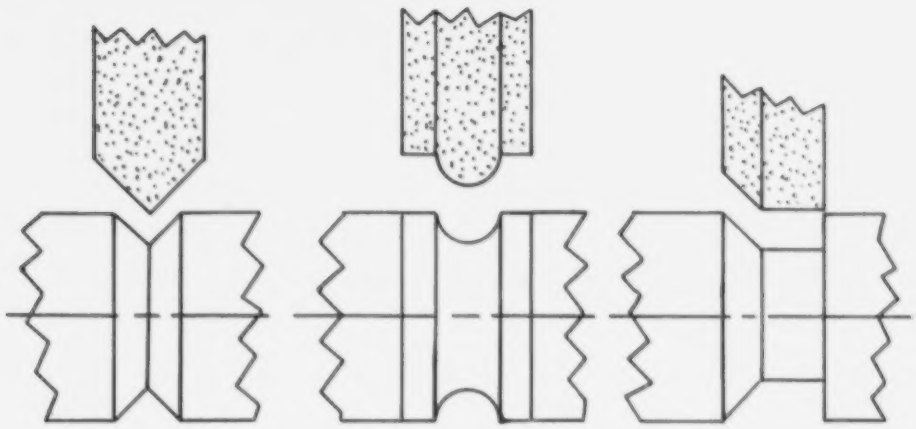
INFORMATION SHEET

H. Plunge or infeed grinding — Grinding a surface or shape by feeding wheel into workpiece with cross feed; can be performed on external or internal surfaces (Figure 11)

(NOTE: Contour grinding is done by plunge or infeed grinding.)

EXAMPLES:

FIGURE 11



III. Procedures for removing and replacing a grinding wheel

A. Removing wheel

1. Remove outer portion of wheel guard
2. Take off spindle nut

(NOTE: The spindle has a left-hand thread.)

3. Use wheel-sleeve puller to loosen sleeve
4. Remove puller, and slide sleeve from tapered spindle
5. Use wrench to remove sleeve from wheel
6. Store wheel if it is not damaged; otherwise, discard

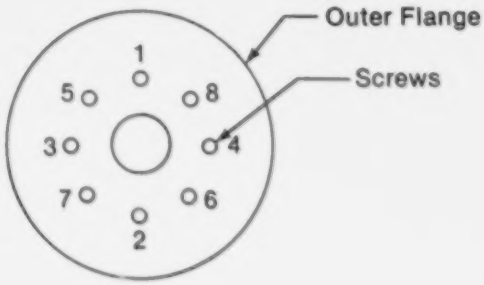
INFORMATION SHEET

B. Mounting wheel

1. Clean spindle and surface of fixed flange and/or wheel sleeve
2. Ring test the grinding wheel
3. Slide wheel and blotters onto wheel sleeve
4. Place outer flange on sleeve, place screws in holes of outer flange, and finger-tighten all screws
5. Use wrench provided by manufacturer, or torque wrench, to tighten all screws snugly in an alternating sequence (Figure 12)

EXAMPLE:

FIGURE 12



(NOTE: Numbers indicate alternating sequence of tightening.)

6. Check wheel balance; balance if necessary
7. Place sleeve on spindle, and secure spindle nut

   (NOTE: Some sleeves are keyed to spindle.)
8. Replace wheel guard
9. Stand to one side, jog start grinder, and allow wheel to reach operating speed and run for one minute

   (NOTE: After eight to twelve hours of grinding, the screws should be retightened to allow for compression of the blotters.)
10. Clean machine, and put away tools

IV. Steps for dressing wheel for cylindrical grinding

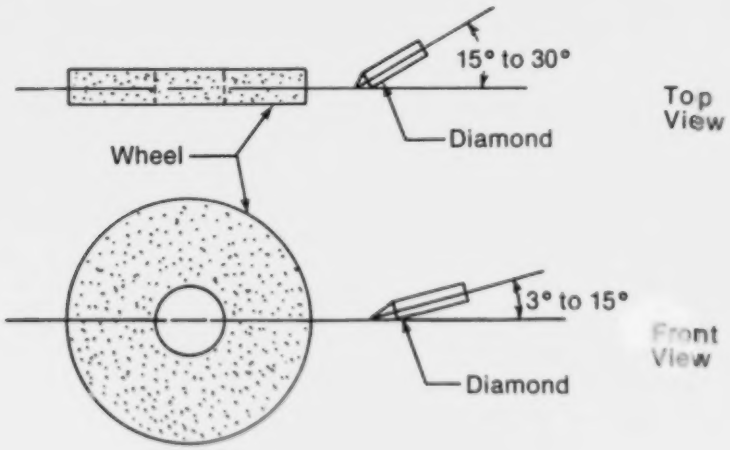
A. Clamp diamond in holder

(NOTE: Holder may be mounted to table or part of the footstock.)

INFORMATION SHEET

B. Position diamond if holder is adjustable (*Figure 13*)

FIGURE 13



C. Start grinder, and allow spindle bearings to warm up

D. Feed wheel so that diamond contacts point at largest diameter on grinding-wheel surface

E. Set table travel at 5 to 10 inches per minute (ipm), or set in truing position indicated by manufacturer

F. Turn on coolant if necessary

(NOTE: Wheel should be dressed the same as it will be used, wet or dry.)

G. Advance wheel 0.0005 inch for each pass across wheel, until face of wheel is completely dressed

H. Position dresser so that it is clear of wheel

I. Stop wheel

(NOTE: If coolant was used, shut off coolant, and allow rotation to continue for one minute before stopping wheel.)

J. Remove diamond and holder if required

K. Clean dust from tools and equipment

INFORMATION SHEET

V. Types of wheel dressers (Transparencies #1 and #2)

A. Footstock-mounted dresser

B. Table-mounted dresser

C. Radius dresser

D. Angle dresser

E. Radius and tangent dresser

F. Crush roll dresser

G. Built-in dresser

VI. Accessories used with cylindrical grinders (Transparencies #3 and #4)

A. Chucks, three- and four-jaw

B. Faceplate

C. Collet chuck

D. Magnetic chuck

E. Center rest

F. Universal backrest with adjustable shoe

G. Headstock and footstock centers

H. Driving dogs

VII. Functions of accessories

A. Chucks — Holding and driving workpieces for external or internal grinding operations

B. Faceplate — Holding and driving workpieces for external or internal grinding operations that cannot be chucked; allows mounting of fixtures

C. Collet chuck — Holding and driving workpieces for external grinding operations of small workpieces that do not vary in size; allows quick clamping

D. Magnetic chuck — Holding and driving thin workpieces that cannot be chucked in a conventional chuck for face grinding

E. Center rest — Supporting long workpieces for external or internal grinding operations

INFORMATION SHEET

F. Universal backrest with adjustable shoe — Supporting long workpieces so that accuracy can be maintained and chatter can be eliminated during grinding operation

G. Headstock and footstock centers — Supporting workpiece at each end for external grinding operations

H. Driving dogs — Driving workpiece held between centers

VIII. Grinding problems and probable causes

A. Chatter

1. Grinding wheel loose on sleeve
2. Wheel too hard
3. Wheel out of round
4. Feed excessive
5. Workpiece not supported properly
6. Work speed too high
7. Table travel too fast
8. Machine vibrating internally
9. Machine improperly mounted or located
10. Centers worn or out of alignment

B. Scratches on finish

1. Coolant dirty
2. Table travel too fast
3. Wheel too soft
4. Wheel too coarse
5. Wheel edge ragged

C. Spirals on finish

1. Workpiece loose on centers
2. Workpiece center holes not true or clean

INFORMATION SHEET

3. Centers fitted poorly in spindles
4. Loose grain particles on wheel
5. Wheel edge ragged
6. Table travel too fast

D. Wavy lines on finish

1. Wheel edge ragged
2. Wheel out of balance
3. Wheel out of round
4. Machine vibrating internally
5. Machine improperly mounted or located
6. Gear action faulty
7. Workpiece too tight on centers

E. Burnt or discolored finish

1. Coolant inadequate
2. Coolant not properly directed
3. Wheel too hard
4. Wheel too fine
5. Grinding wheel material wrong
6. Wheel loaded or glazed
7. Wheel speed too high
8. Workpiece speed too low
9. Table travel too fast
10. Feed excessive

INFORMATION SHEET

F. Feed line on finish

1. Grinding wheel material wrong
2. Wheel edge ragged
3. Workpiece not supported properly
4. Centers worn or out of alignment
5. Coolant not properly directed
6. Table travel incorrect

G. Inaccuracies in workpiece

1. Centers worn or out of alignment
2. Centers fitted poorly in spindle
3. Gibs loose or table ways worn
4. Headstock or swivel table not properly aligned
5. Workpiece loose on centers
6. Workpiece center holes not true or clean
7. Workpiece too hot
8. Wheel loaded or glazed

H. Intermittent cutting action

1. Workpiece too tight on centers
2. Workpiece too hot
3. Workpiece out of balance
4. Wheel out of balance
5. Wheel out of round
6. Coolant not properly applied

INFORMATION SHEET

IX. Work and wheel rotation — Grinders may operate so that the wheel and workpiece rotate in the same or in opposite directions; however, at the point of contact, the surfaces rotate in opposite directions (Figures 14 and 15)

EXAMPLES:

FIGURE 14 OD grinding

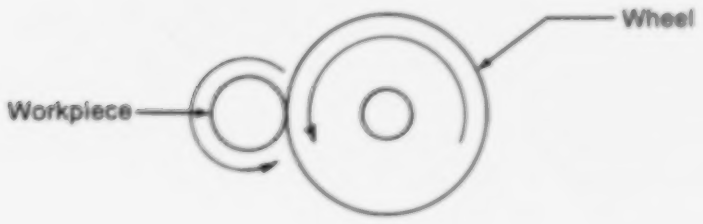
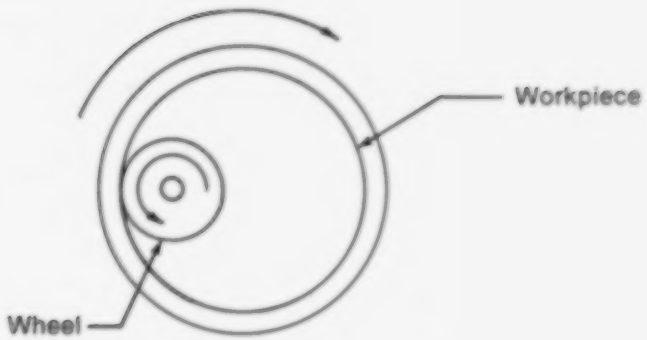


FIGURE 15 ID grinding



INFORMATION SHEET

X. Steps in calculating wheel speed (rpm), work speed, and rate of table travel (ipm) (Assignment Sheet #2)

A. Wheel speed (rpm)

(NOTE: Wheel speed [rpm] is often called *spindle speed*.)

1. Check the manufacturer's maximum recommended wheel speed (sfpm)

(NOTE: The maximum wheel speed [sfpm] is written on the paper blotter or the wheel.)

2. Determine wheel speed (rpm) using the formula

$$\text{Wheel Speed (rpm)} = \frac{\text{Wheel Speed (sfpm)} \times 3.8}{\text{Wheel Diameter (D)}}$$

(NOTE: The number 3.8 is a constant. The actual formula for wheel speed [rpm] is

$$\text{Wheel Speed (rpm)} = \frac{\text{Wheel Speed (sfpm)} \times 12}{\pi \times \text{Wheel Diameter (D)}}$$

The number 12 is a constant. Twelve divided by pi is approximately 3.8.)

EXAMPLE: To operate a 10-inch diameter wheel at 6,000 sfpm —

$$\text{Wheel Speed (rpm)} = \frac{\text{Wheel Speed (sfpm)} \times 3.8}{\text{Wheel Diameter (D)}}$$

$$= \frac{\text{sfpm} \times 3.8}{\text{D}}$$

$$= \frac{6{,}000 \times 3.8}{10}$$

$$= 2{,}280 \text{ rpm}$$

3. Use wheel speed (rpm) closest to calculated speed, but do not exceed calculated speed

(NOTE: Some grinders have changeable driving sleeves so that the wheel speed [rpm] can be adjusted. Check operator's manual for speeds using different sleeves.)

B. Work speed

(NOTE: Work speed for grinding is calculated so that material will turn at a required cutting speed [CS].)

1. Determine cutting speed

a. Use cutting-speed charts to determine cutting speed of material being ground

b. If cutting-speed charts are not available, use 50 feet per minute for external grinding and 100 feet per minute for internal grinding

2. Multiply cutting speed by 4, and divide by diameter of workpiece

EXAMPLE: For external grinding of a 2-inch diameter bar —

$$\text{Work Speed} = \frac{\text{Cutting Speed (CS)} \times 4}{\text{Workpiece Diameter (D)}}$$

$$= \frac{CS \times 4}{D}$$

$$= \frac{50 \times 4}{2}$$

$$= 100 \text{ rpm}$$

C. Rate of table travel (ipm)

1. For rough grinding, set table travel at one-half to two-thirds the wheel width per revolution of workpiece

2. For finish grinding, set table travel at ⅛ to ½ inch per revolution of workpiece

3. Multiply work speed times the distance in inches that workpiece should travel per revolution

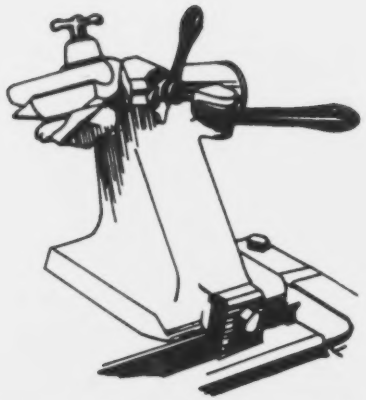
EXAMPLE: For rough grinding using a 1-inch-wide wheel and a work speed of 100 rpm—

Rate of Table Travel = Work Speed × Table Travel per Revolution

= 100 rpm × 0.5 inches

= 50 ipm

Types of Wheel Dressers



Footstock-Mounted Dresser

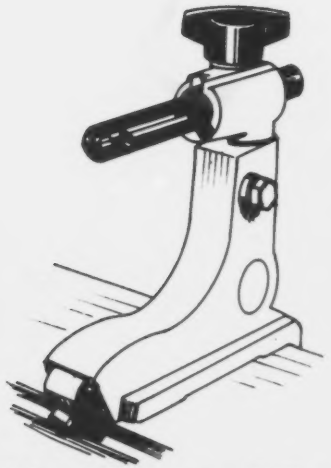
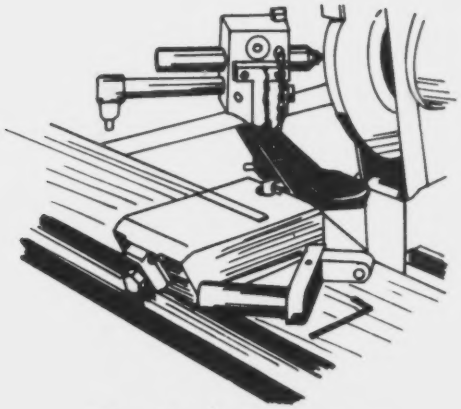
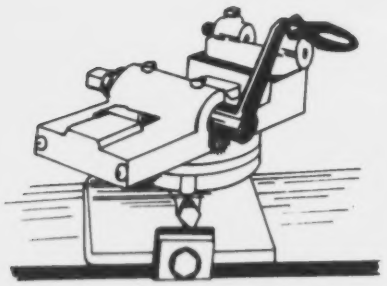


Table-Mounted Dresser

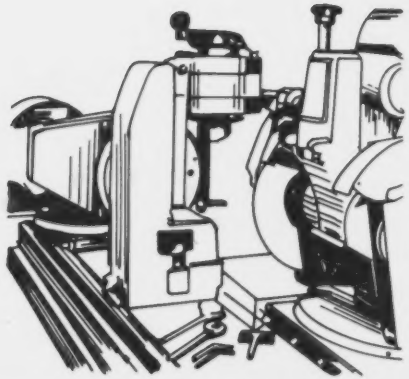


Radius Dresser

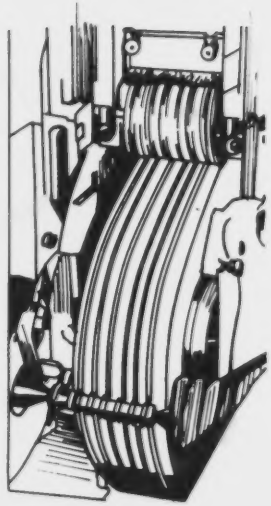


Angle Dresser

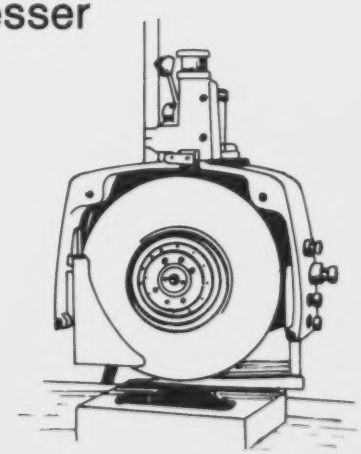
Types of Wheel Dressers
(Continued)



Radius and Tangent Dresser

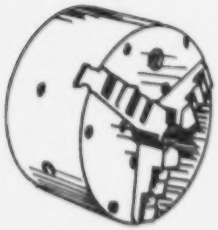


Crush Roll Dresser

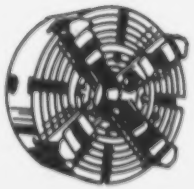


Built-in Dresser

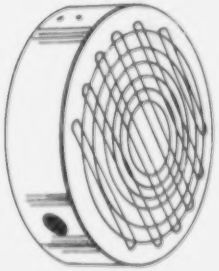
Accessories Used with Cylindrical Grinders



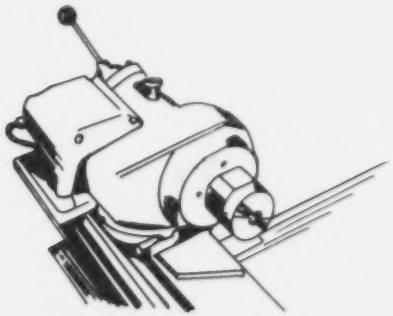
Three-Jaw Chuck



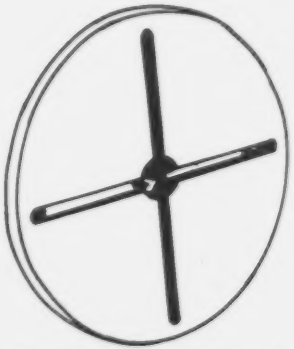
Four-Jaw Chuck



Magnetic Chuck

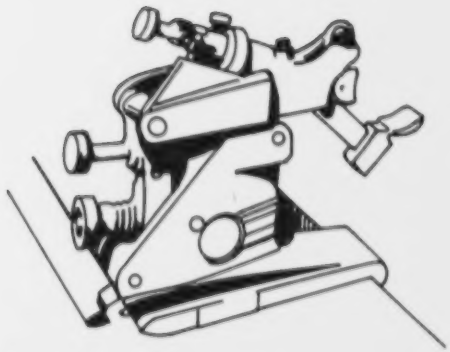


Collet Chuck

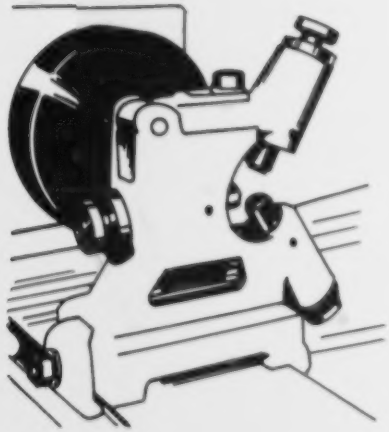


T-Slot Faceplate

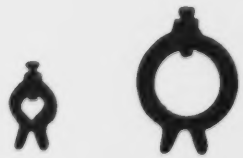
Accessories Used with Cylindrical Grinders
(Continued)



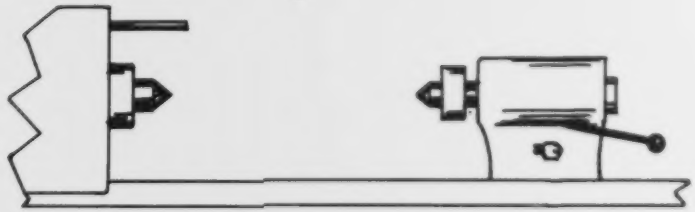
Universal Backrest with
Adjustable Shoe



Center Rest



Driving Dogs



Headstock and
Footstock Centers

CYLINDRICAL GRINDING
UNIT III

ASSIGNMENT SHEET #1 — IDENTIFY
CYLINDRICAL GRINDING OPERATIONS

NAME _____ SCORE _____

The ability to identify grinding operations is a skill that will help you plan the sequence of operations and determine methods of holding workpieces.

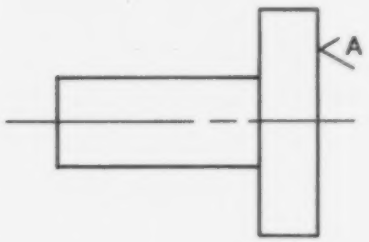
In the blanks provided, write each type of cylindrical grinding operation described and illustrated below and on the following pages.

(NOTE: Some illustrations may represent more than one type of operation. Answers may be used more than once.)

Straight grinding
Taper grinding
Shoulder grinding
Contour grinding
Internal grinding
Face grinding
Angular grinding
Plunge or infeed grinding

A. Grinding surface A 90 degrees to center axis of workpiece

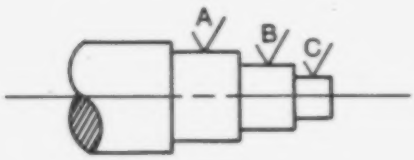
_____



B. Grinding surfaces A, B, and C at one time so that all surfaces are concentric to center axis

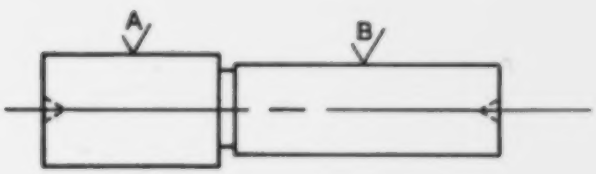
_____

_____

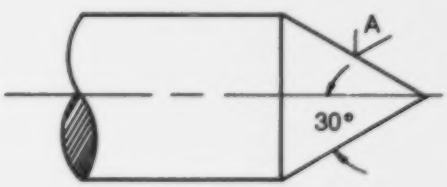


ASSIGNMENT SHEET #1

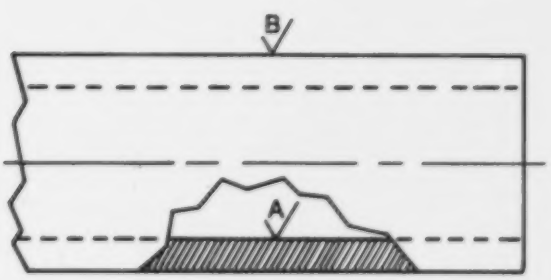
C. Grinding surfaces A and B true to center axis of shaft



D. Grinding surface A 30 degrees to center axis

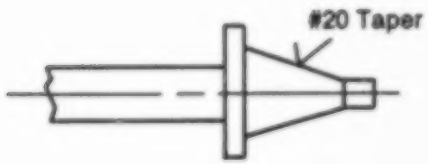


E. Grinding surface A true to surface B

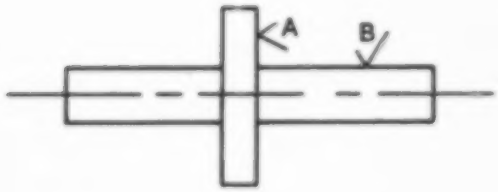


ASSIGNMENT SHEET #1

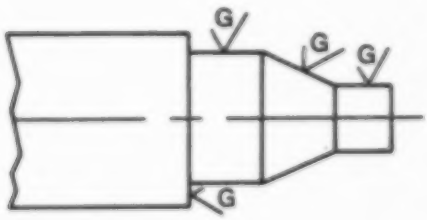
F. Grinding a #20 machine taper on the end of an arbor



G. Grinding surface A 90 degrees to surface B



H. Grinding the shape indicated true to center axis of workpiece

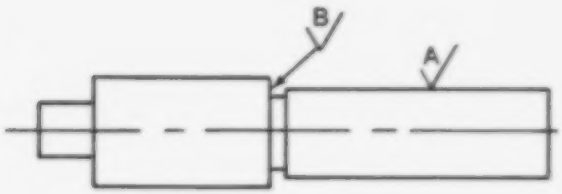


ASSIGNMENT SHEET #1

I. Grinding surfaces A and B so that A is true to center and B is 90 degrees to A

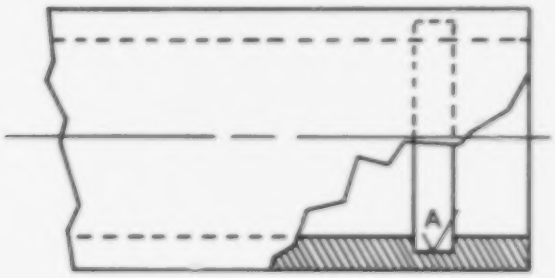
Surface A _____

Surface B _____



J. Grinding surface A concentric to bore

_____



CYLINDRICAL GRINDING
UNIT III

ASSIGNMENT SHEET #2 — CALCULATE WHEEL SPEED (rpm), WORK SPEED, AND RATE OF TABLE TRAVEL (ipm)

NAME _____ SCORE _____

In grinding, the safe and efficient removal of material depends on the use of proper speeds and rates of table travel. If the wheel turns too fast, it may explode. If the wheel or workpiece rotates too slowly, a great deal of time can be wasted. Additionally, improper speeds and rate of table travel can lead to such grinding problems as poor surface finishes and chatter. For these reasons, it is vitally important that you be able to calculate wheel speed (rpm), work speed, and rate of table travel (ipm) correctly.

Read the problems below, and answer the questions about grinding speeds. If necessary, refer to Section X of the Information Sheet for calculation steps and formulas.

(NOTE: For this assignment, use $^2/_3$ or 0.67 in calculating rate of table travel for rough grinding. Use $^1/_4$ inch or 0.25 inch in calculating rate of table travel for finish grinding.)

A. Calculate wheel speed for a 10-inch diameter wheel if the recommended surface speed is 6,500 sfpm.

_____ rpm

B. Calculate wheel speed for an 8-inch diameter wheel if the recommended surface speed is 6,000 sfpm.

_____ rpm

ASSIGNMENT SHEET #2

C. Calculate work speed needed to grind the surface of a steel shaft 2⅝ inches in diameter.

_____ rpm

D. Calculate work speed needed to finish a 1.5-inch bore in a pipe.

_____ rpm

E. Calculate the rate of table travel to rough grind a shoulder on a 2.0-inch diameter round bar using a wheel ¾ of an inch wide.

_____ ipm

ASSIGNMENT SHEET #2

F. Calculate the rate of table travel to finish grind a steel shaft 3.25 inches in diameter with a ½-inch wheel.

_____ ipm

G. If a 2¼-inch diameter hardened steel shaft is to be ground using a 1-inch wide, 10-inch diameter wheel and a surface speed of 6,200 sfpm, what is

1. the wheel speed? _____ rpm
2. the work speed? _____ rpm
3. the rate of table travel for rough grinding? _____ ipm
4. the rate of table travel for finish grinding? _____ ipm

ASSIGNMENT SHEET #2

H. In problem G, if the machine being used has wheel speed settings of 2,000 rpm, 2,250 rpm, and 2,500 rpm, which wheel speed should be used?

_____ rpm

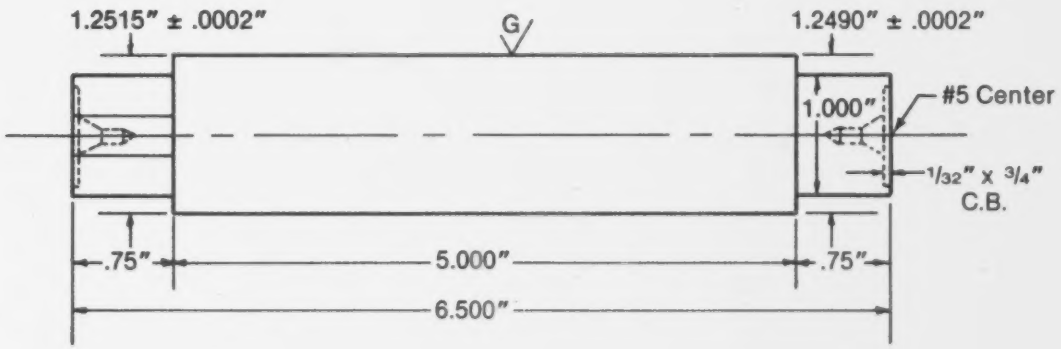
CYLINDRICAL GRINDING
UNIT III

ASSIGNMENT SHEET #3 — PLAN PROCEDURES
FOR GRINDING A TAPERED MANDREL

NAME _____ SCORE _____

To do the work involved in parts production, you must be able to look at a blueprint or plan and determine the operations required and the tools needed to perform the job.

Examine the plan for a tapered mandrel shown below, and determine the grinding tools and procedures required to produce the mandrel.



Mandrel SAE 4140

(NOTE: The workpiece has been turned to a 1.270-inch diameter along its full length. The centers have been drilled and counterbored.)

ASSIGNMENT SHEET #3

A. List the tools and equipment needed to grind the mandrel.

1. _____ 4. _____

2. _____ 5. _____

3. _____ 6. _____

B. List in order the steps required to grind the mandrel.

_____

_____

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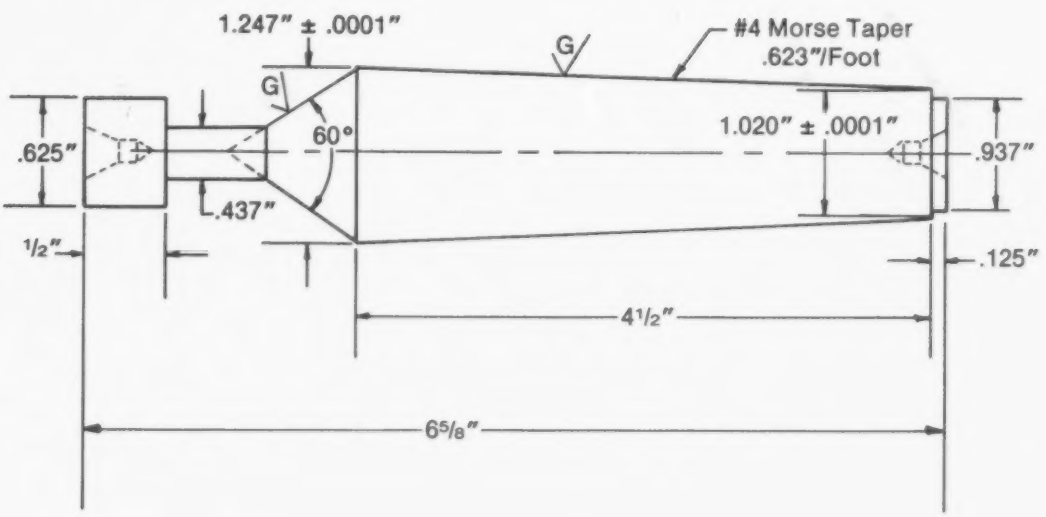
CYLINDRICAL GRINDING
UNIT III

ASSIGNMENT SHEET #4 — PLAN PROCEDURES
FOR GRINDING A LATHE CENTER

NAME _____ SCORE _____

Careful planning of tool and equipment requirements and procedures before starting a job helps to eliminate wasted time.

Examine the plan for a lathe center shown below. Determine the tools and equipment needed and the grinding procedures required to produce both tapers on this lathe center.



(NOTE: Only the tapered areas need to be ground. Assume that the tapers have been turned with 0.015 inch of material left for grinding.)

ASSIGNMENT SHEET #4

A. List tools and equipment required for grinding lathe center tapers.

1. _____ 7. _____
2. _____ 8. _____
3. _____ 9. _____
4. _____ 10. _____
5. _____ 11. _____
6. _____ 12. _____

B. List in order the steps required to grind to dimension the two tapers on the lathe center.

_____

_____

_____

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CYLINDRICAL GRINDING
UNIT III

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A. Face grinding

B. Plunge or infeed grinding; contour grinding

C. Straight grinding

D. Angular grinding

E. Internal grinding

F. Taper grinding

G. Shoulder grinding; face grinding

H. Plunge or infeed grinding; contour grinding

I. Surface A — straight grinding; surface B — shoulder grinding

J. Internal grinding

Assignment Sheet #2

A. 2,470 rpm

B. 2,850 rpm

C. 76.2 rpm

D. 266.6 rpm

E. 50.2 ipm

F. 30.7 ipm

G. 1. 2,356 rpm

2. 88.8 rpm

3. 59.5 ipm

4. 22.2 ipm

H. 2,250 rpm

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #3

(NOTE: The tools, equipment, and procedures may vary depending on availability and instructor's preference.)

A. Tools and equipment

1. Grinder with centers, coolant, and driving plate
2. Wheel dresser with diamond
3. Micrometer, 1- to 2-inch
4. Work-driving dog
5. Dressing stick
6. Wrenches for headstock, swivel table, and footstock

B. Procedures

1. Set headstock to zero
2. Put driving dog on flat end of workpiece
3. Place workpiece between centers, and adjust footstock
4. Remove workpiece
5. Mount dresser, and dress grinding wheel
6. Set work speed and table speed
7. Put workpiece between centers
8. Adjust right and left table dogs
9. Set automatic feed for feed depth (0.0005 inches)
10. Set swivel table
11. Grind workpiece
12. Check workpiece
13. Adjust setup if necessary
14. Grind workpiece to size

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #4

(NOTE: The tools, equipment, and procedures may vary depending on the availability and instructor's preference.)

A. Tools and equipment

1. Grinder with centers, coolant, driving plate, and four-jaw chuck
2. Morse socket, #4
3. Dial test indicator with magnetic base
4. Work-driving dog
5. Prussian blue
6. Cloth
7. Wrenches for headstock, swivel, swivel table, and chuck
8. Center lubricant (not lead)
9. Test bar for setting taper
10. One-inch travel indicator with magnetic base
11. Table-type wheel dresser with diamond
12. Dressing stick
13. Micrometer, 1- to 2-inch

B. Procedure

1. Set headstock to zero
2. Set and adjust footstock with test bar between centers
3. Set work speed
4. Set table speed
5. Set taper
6. Remove test bar
7. Dress wheel
8. Put lubricant in centers

ANSWERS TO ASSIGNMENT SHEETS

9. Put work-driving dog on 0.625-inch diameter
10. Set workpiece between centers
11. Adjust table dogs
12. Grind length of taper
13. Chuck taper in socket
14. Adjust if necessary
15. Grind to dimension
16. Remove workpiece
17. Remove center from headstock
18. Remove driving plate
19. Mount chuck to headstock
20. Chuck on tapered socket
21. Align workpiece
22. Grind off excess from 0.625-inch end with pedestal grinder
23. Seat workpiece in socket
24. Set headstock to grind a 60-degree included angle
25. Set table dogs
26. Grind angle

CYLINDRICAL GRINDING
UNIT III

JOB SHEET #1 — REMOVE AND REPLACE A GRINDING WHEEL

I. Equipment and materials

A. Wrench to remove wheel guard

B. Wrench to remove spindle nut

C. Wheel-sleeve puller

D. Wrench to remove outer wheel flange

E. Grinding wheel (correct size to fit machine)

F. Plastic-handled screwdriver

G. Wooden dowel, 1-inch diameter, 4 to 5 inches long

H. Shop towels

I. Cylindrical grinding machine

II. Procedure to remove wheel

A. Remove outer portion of wheel guard

B. Remove spindle nut

(NOTE: Spindle has left-hand threads.)

C. Screw wheel-sleeve puller into spindle, and tighten puller screw until taper of wheel sleeve is loosened from spindle

(CAUTION: Never try to loosen the wheel sleeve from the spindle by pulling or tapping on the wheel; the wheel can be cracked.)

D. Remove wheel sleeve and wheel as one unit, and place it with bolts up on a bench

E. Remove screws from wheel

F. Remove outer flange from sleeve

G. Remove sleeve from grinding wheel

H. Store or discard grinding wheel

JOB SHEET #1

III. Procedure to mount wheel

A. Clean spindle and surfaces of fixed flange and/or wheel sleeve

B. Ring test grinding wheel

C. Slide wheel and blotters onto wheel sleeve

(CAUTION: Never force the wheel onto the sleeve or alter the hole size.)

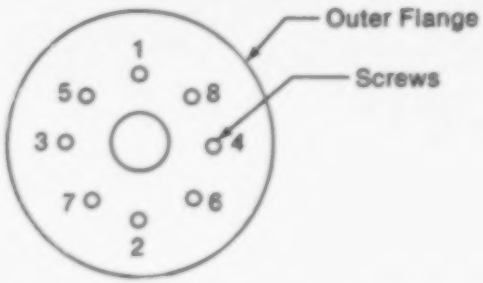
D. Place outer flange on sleeve

E. Start and finger-tighten all screws

F. Use wrench provided by manufacturer to tighten all screws snugly in alternating sequence (Figure 16)

(CAUTION: Do not overtighten screws; too much pressure from bolts can crack wheel.)

FIGURE 16



(NOTE: Numbers indicate alternating sequence of tightening.)

G. Check balance of wheel; balance if necessary

H. Place sleeve on spindle, and tighten spindle nut

I. Replace wheel guard

J. Stand to one side and jog start grinder; allow wheel to reach operating speed and run for one minute

K. Dress wheel

(NOTE: After eight to twelve hours of grinding, the flange screws should be retightened to allow for compression of the blotters.)

L. Have instructor check your work

M. Clean machine, and put away tools

CYLINDRICAL GRINDING
UNIT III

JOB SHEET #2 — USE TABLE-MOUNTED HOLDER TO DRESS A GRINDING WHEEL

I. Equipment and materials

A. Cylindrical grinder with wheel mounted

B. Single-point diamond

C. Table-mount diamond holder

D. Wrenches

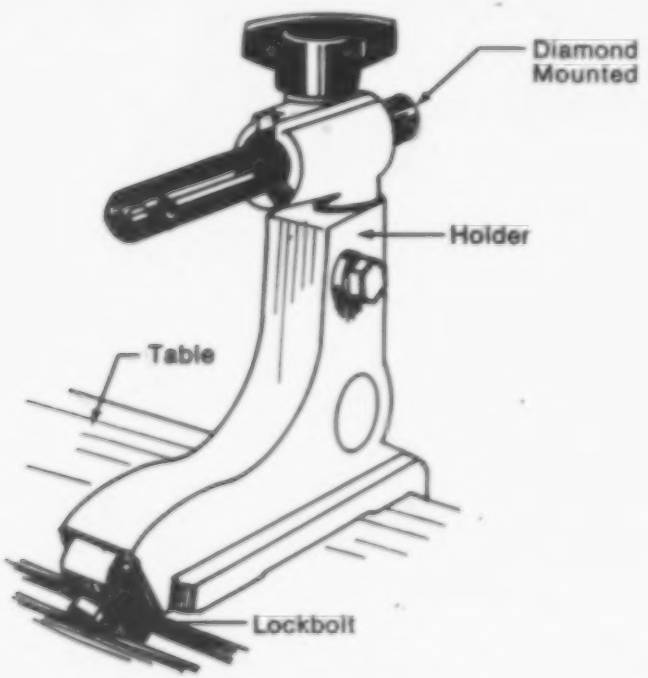
E. Shop towels

II. Procedure

A. Place diamond in table-mount holder so that its point is as close to holder as possible; tighten until diamond is snug

B. Mount holder at center of table, and secure lockbolt (Figure 17)

FIGURE 17

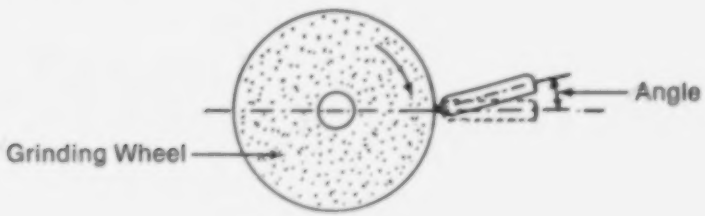


JOB SHEET #2

C. If holder is adjustable, position diamond slightly downward to prevent gouging (Figure 18)

(NOTE: Some table-mount holders have a built-in downward angle.)

FIGURE 18



D. Adjust diamond to center height; tighten adjustment bolt and diamond lockscrew

E. Adjust stops so that point of diamond clears each side of wheel width about 1 inch

F. Put table in truing position, or set table feed for 5 to 10 inches per minute

G. Start grinding wheel, and allow it to run until bearings have warmed up (about five minutes)

H. Position diamond near center of wheel

I. Using cross feed, move wheel to diamond until diamond cuts high point

J. Move diamond to right side of wheel

K. Start coolant

L. Advance wheel 0.0005 inch, and engage power feed

(NOTE: Dressing the wheel with the coolant running will keep the diamond cooler, clean the wheel, and keep the dust out of the air.)

M. Continue to advance wheel 0.0005 inch per pass until face of wheel has been dressed smooth and flat

N. Stop table travel with diamond at one side of wheel

O. Turn off coolant; allow wheel to run for about one minute

P. Stop spindle and examine wheel

Q. Have instructor inspect your work

JOB SHEET #2

R. Clean machine, and put away all tools

(NOTE: The wheel may need to be dressed during grinding operations. To dress wheel, remove the workpiece or use a footstock-type holder. If the wheel is dressed when it first starts to load or dull, material can be removed at a faster rate and the quality of the finish can be maintained.)

CYLINDRICAL GRINDING
UNIT III

JOB SHEET #3 — GRIND A WORKPIECE STRAIGHT AND TO SIZE

I. Equipment and materials

A. Cylindrical grinder with coolant, centers, and general-purpose grinding wheel mounted

B. Diamond in holder

C. Micrometer, 1- to 2-inch

D. Universal backrest

E. Shop towels

F. Center lubricant

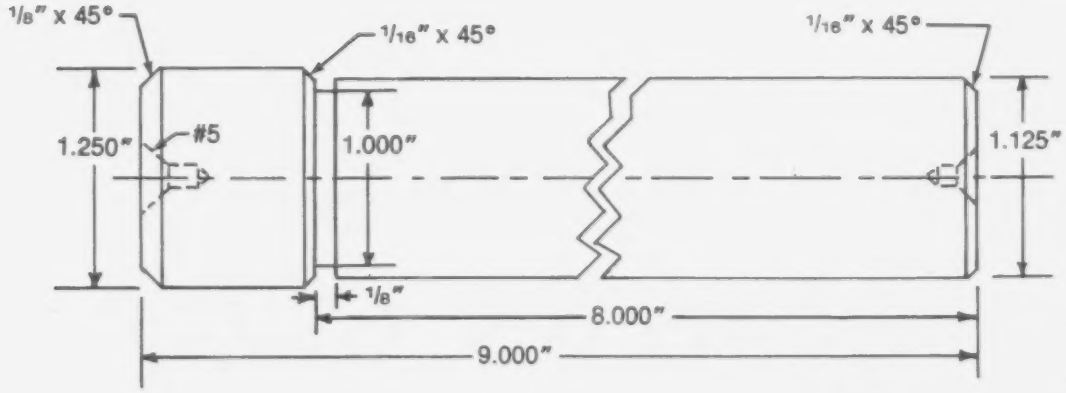
G. Work-driving dog, 1 1/4-inch

H. Dial test indicator and holder

I. SAE 4140 steel bar, 1 1/4-by-9 1/8-inch, premachined and heat-treated to 58 C (Figure 19)

FIGURE 19

Test Bar



(NOTE: The 1.125-inch dimension has been turned to 1.145 inches and requires grinding to size.)

JOB SHEET #3

II. Procedure

(NOTE: It may be necessary to modify this procedure for some models of grinders.)

A. Clean grinder table

B. Set headstock to zero

1. Loosen headstock swivel clamp bolts

2. Swivel headstock to zero reading

3. Retighten swivel clamp bolts

C. Loosen table clamps, and turn adjusting nut to set swivel table at zero; tighten table clamps

D. Put work-driving dog on large end of workpiece and tighten

E. Compress spring in tailstock slightly and set in place

F. Inspect centers of workpiece for cleanliness and irregularities

G. Put lubricant in center hole at each end of workpiece

H. Place workpiece on headstock center so that work-driving arm is in the "V" of the driving dog

I. Slide footstock toward workpiece until center engages in hole; snug footstock clamp

J. Loosen footstock spindle clamp, and pull operating lever to check to see that workpiece can be removed

(NOTE: The center of the footstock should retract enough to allow the workpiece to be removed. If workpiece cannot be removed, footstock must be adjusted.)

(CAUTION: Never operate grinder with spindle clamp tightened.)

K. Set wheel speed for 5,600 sfpm

(CAUTION: Check the speed rating of the grinding wheel. Never exceed the safe operating range.)

L. Set work speed at 175 rpm

JOB SHEET #3

M. Dress wheel

(NOTE: It may be necessary to remove the workpiece to dress the wheel.)

N. Clean table

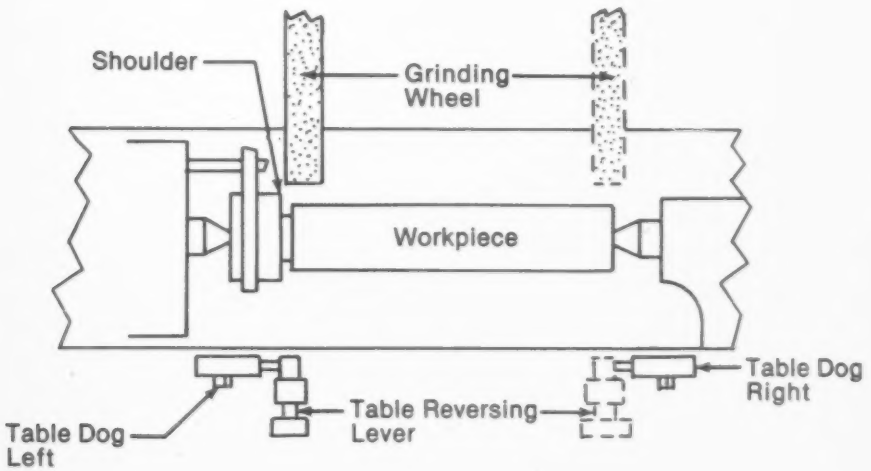
O. Set table travel at 25 ipm

(NOTE: This table travel is based on 1/8 inch of travel per revolution of workpiece.)

P. Mount and adjust universal backrest

Q. Set the table dogs so that table reverses when wheel is almost to shoulder at left end of workpiece, and when center of wheel reaches right end of workpiece (Figure 20)

FIGURE 20



R. Start wheel, and adjust coolant flow

S. Start workpiece and table

T. Set table dwell right and left for two seconds

U. Set automatic cross feed to feed left; set feed rate at 0.001 inch per stroke

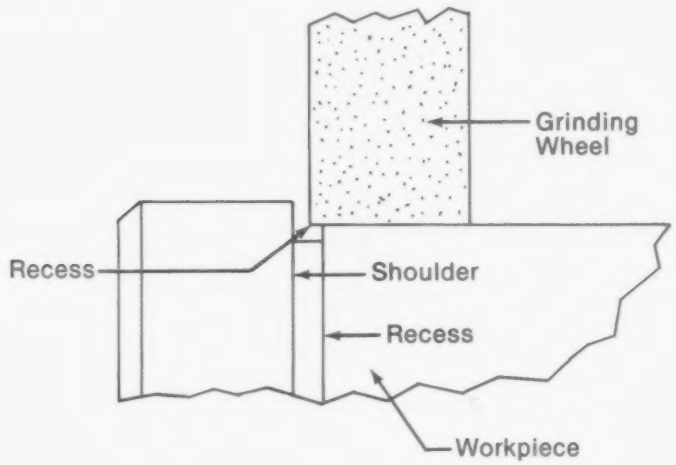
V. Bring wheel to workpiece until wheel starts to spark

(CAUTION: As you bring the wheel to the work, make sure that the table reverses before the left side of the wheel reaches the shoulder of the workpiece.)

JOB SHEET #3

W. Use adjusting screw knob to set left table dog to allow table travel, until left edge of wheel is at middle of recess (Figure 21)

FIGURE 21



X. Engage automatic feed, and allow feed to advance until workpiece is ground along full length of table travel

Y. Disengage power feed; move wheel one revolution of handwheel away from workpiece

(NOTE: On some machines the power feed will automatically disengage when the fixed stop of the cross-feed handwheel makes contact with the switch operating slide.)

Z. Stop coolant, table, and workhead

AA. Measure workpiece at right end and near the shoulder

BB. If the two measurements are the same, set indexing dial to allow wheel to grind workpiece to size

CC. If the two measurements are not the same, adjust swivel table as required

DD. Start coolant and workhead

EE. Grind workpiece to size

FF. Stop coolant and machine; allow wheel to run for several minutes to remove coolant

GG. Stop wheel; remove work from centers

HH. Clean machine, and put away all tools

II. Turn in workpiece to instructor for evaluation

CYLINDRICAL GRINDING
UNIT III

JOB SHEET #4 — GRIND A WORKPIECE TO DIMENSION

I. Equipment and materials

A. Cylindrical grinder with coolant, centers, and general-purpose grinding wheel mounted

B. Diamond in table-mount holder

C. Shop towel

D. Work-driving dogs

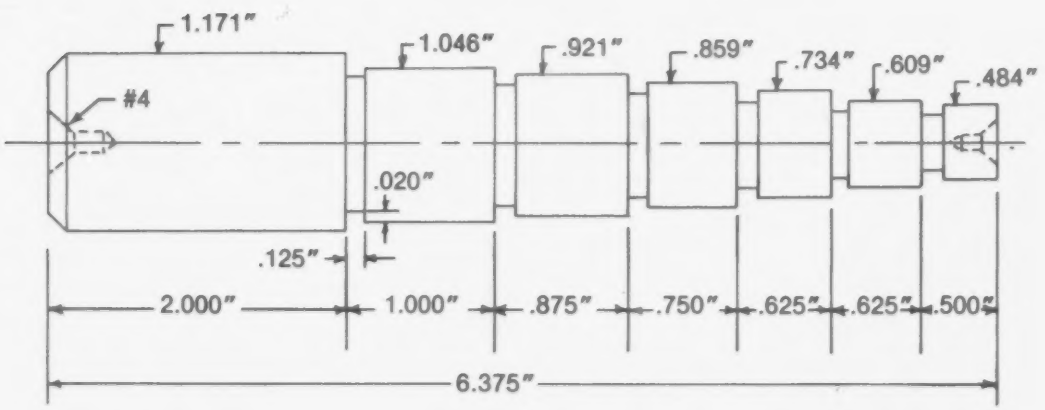
E. Micrometer, 1- to 2-inch

F. Micrometer, 0- to 1-inch

G. SAE 4140 steel bar, 1¼-by-6½-inch, premachined and heat-treated to 58 C (Figure 22)

FIGURE 22

Bushing Drift



(NOTE: All diameters on workpiece to be ground are 0.020 inch larger than finished dimensions.)

JOB SHEET #4

II. Procedure

A. Set headstock to zero

B. Set swivel table to zero

C. Put work-driving dog on small diameter of workpiece

D. Adjust and set footstock to proper tension so that workpiece can be removed without moving footstock

E. Set wheel speed at about 5,600 sfpm

F. Set work speed at 175 rpm

G. Dress wheel

(NOTE: It may be necessary to remove workpiece before dressing wheel.)

H. Clean table

I. Set table feed for 25 ipm

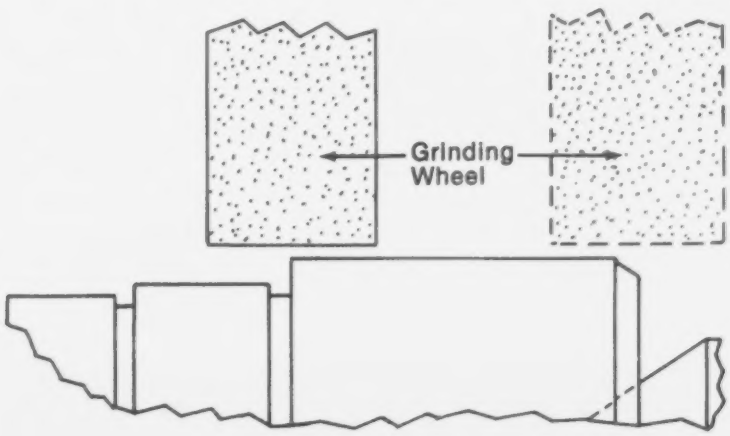
J. Set headstock for dead-center grinding

K. Lubricate both ends of workpiece

L. Place workpiece between centers

M. Adjust table dogs so that edges of surface to be ground are in center of wheel at limits of table travel (Figure 23)

FIGURE 23



JOB SHEET #4

N. Set automatic feed for 0.005 inch

O. Set right and left dwells for two seconds

P. Set feed right

Q. Start grinding wheel and workpiece

R. Bring wheel to workpiece until it just sparks

S. Turn on coolant and adjust flow

T. Start table traversing, and engage power feed

U. Grind surface from edge to edge

V. Move wheel back one revolution of cross feed; measure workpiece near each end of ground surface; align table if required

W. Note diameter of workpiece, and set index dial

X. Start wheel, workpiece, and table

Y. Bring wheel to workpiece until it starts to spark

Z. Engage automatic feed; allow wheel to grind to the stop and spark out

AA. Move wheel back one revolution of cross-feed handwheel

BB. Measure workpiece, and repeat grinding as necessary

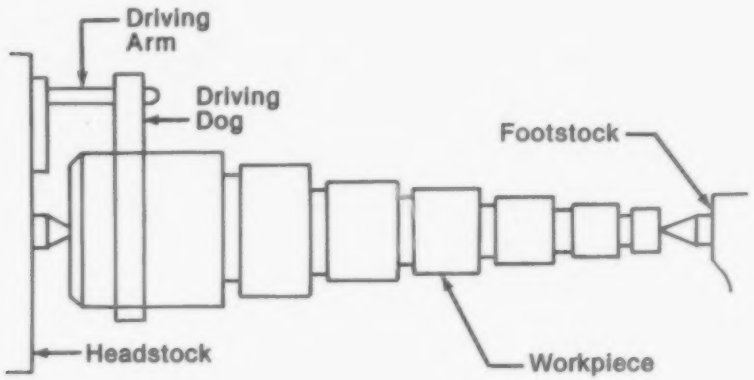
CC. Remove workpiece from centers

DD. Stop machine

EE. Remove work-driving dog from small diameter, and place driving dog on large diameter (surface just ground)

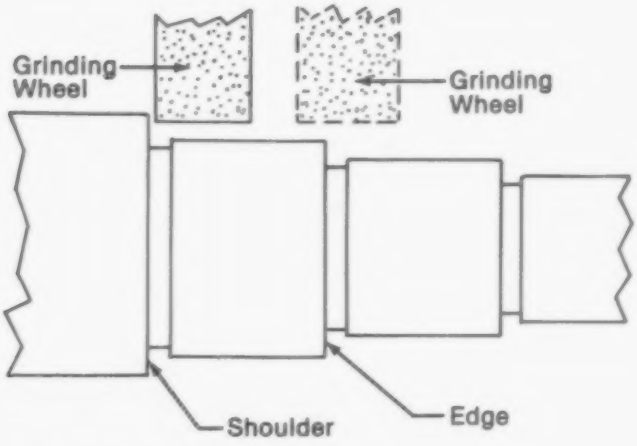
FF. Place workpiece between centers with driving arm in "V" of work-driving dog (Figure 24)

FIGURE 24



GG. Adjust left table dog so that left side of wheel is near shoulder; adjust right dog so that edge of surface to be ground is under center of wheel at limits of table travel (Figure 25)

FIGURE 25



HH. Start wheel, workpiece, and table

II. Use fine adjustment knob to adjust left table dog until left side of wheel sparks shoulder

JOB SHEET #4

JJ. Bring wheel to workpiece until it sparks; grind diameter the entire length of workpiece

KK. Move wheel back one revolution of cross-feed handwheel

LL. Stop workpiece and measure diameter

MM. Set indexing dial; grind surface to dimension

NN. Repeat procedure for remaining surfaces

OO. After last surface is ground to size, move wheel away from workpiece

PP. Stop workpiece, coolant, and table

QQ. Allow wheel to rotate for one minute to remove coolant; stop wheel

RR. Remove workpiece

SS. Clean machine, and put away all tools

TT. Turn in workpiece to instructor for evaluation

CYLINDRICAL GRINDING
UNIT III

JOB SHEET #5 — GRIND A #4 MORSE TAPER

I. Equipment and materials

A. Cylindrical grinder with coolant, centers, and general-purpose grinding wheel mounted

B. Diamond in holder

C. Work-driving dog

D. Work-driving plate

E. Clean shop towels

F. Prussian blue

G. Morse sleeve or Morse ring (socket) gauge, #4

H. Travel dial indicator with magnetic base, 1-inch

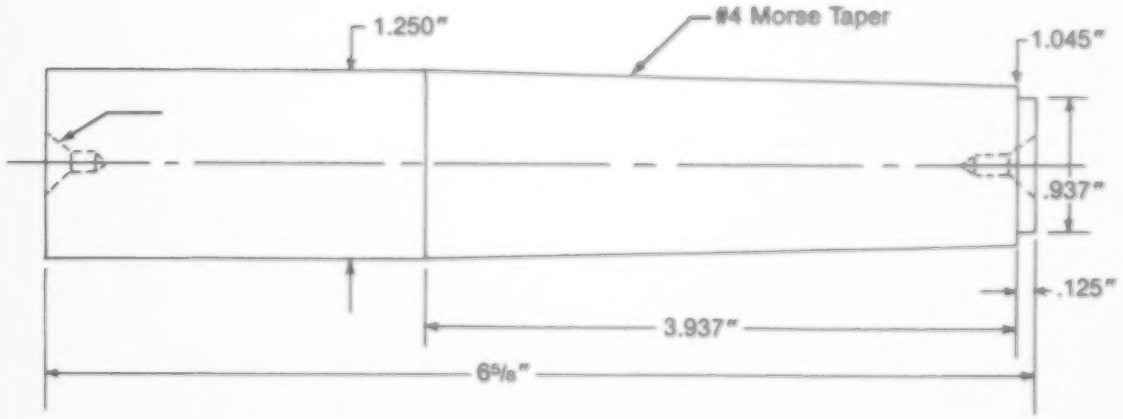
I. Travel dial indicator with magnetic base, ¼-inch

J. Test bar same length as workpiece

K. Sandpaper

L. SAE 4140 steel bar, 1¼-by-6¾-inch, premachined and heat-treated to 58 C (Figure 26)

FIGURE 26



JOB SHEET #5

II. Procedure

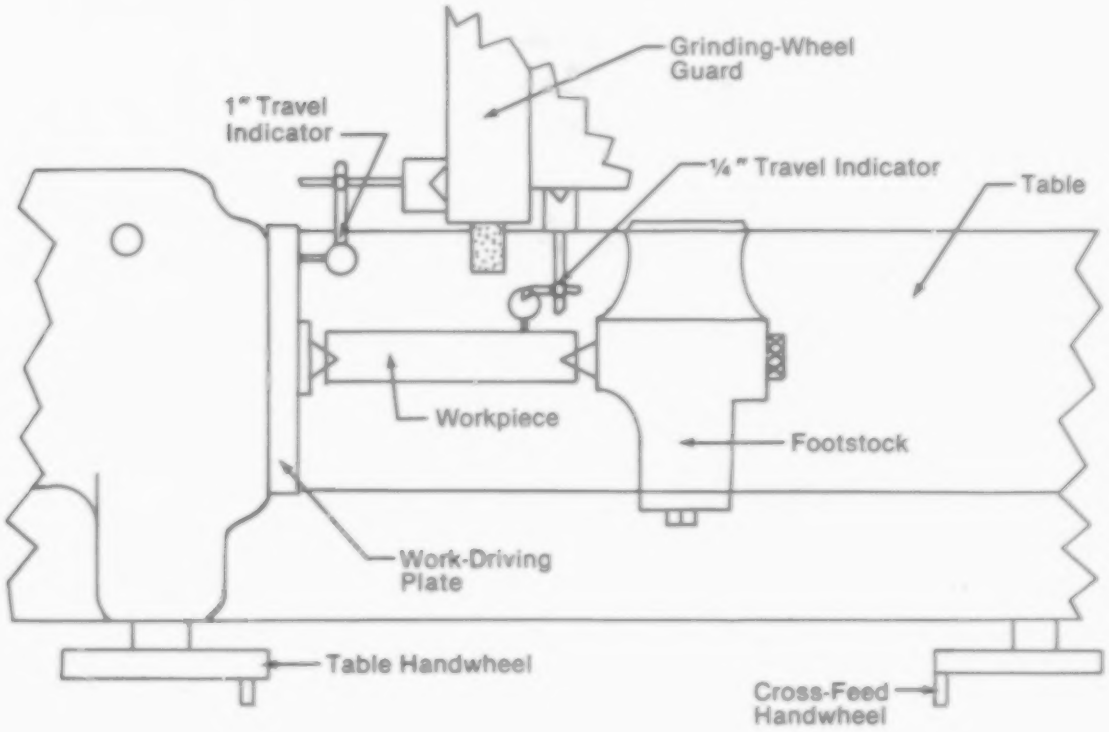
A. Set headstock to zero

B. Place test bar between centers so that it can be removed and replaced by workpiece without moving footstock

C. Mount ¼-inch travel dial indicator to wheel head so that indicator plunger is on test bar near right end of workpiece

D. Mount 1-inch travel dial indicator independent of table so that plunger can be placed to read distance table moves right (Figure 27)

FIGURE 27



JOB SHEET #5

E. Crank workhead to workpiece so that indicator contacts workpiece with a 0.030-inch load

F. Move table left until indicator touching work-driving plate has moved 1 inch

G. Loosen table clamp bolts at each end of swivel table, and move swivel table to a setting of 0.623 inch per foot, or about 1½ degrees

(NOTE: The right end of the swivel table will move away from you to produce a taper with the small diameter at the footstock end or right end of the workpiece.)

H. Zero the two indicators

I. Move table right 1 inch to the zero setting of indicator touching work-driving plate

J. Note reading of indicator touching workpiece

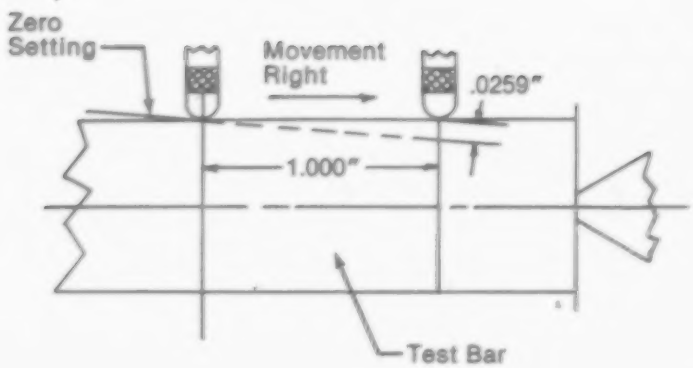
(NOTE: If table setting is correct, the movement of the indicator will be 0.0259 inch. See Figure 28.)

EXAMPLE: 0.623" = Total difference of diameters per foot

0.623" ÷ 12 = 0.0519" (Difference of diameters per inch)

0.0519" ÷ 2 = 0.0259" (Difference on one side of the workpiece)

FIGURE 28



JOB SHEET #5

K. Adjust swivel table if necessary

L. Snug bolts at each end of swivel table so that table will not move

(NOTE: Do not overtighten.)

M. Remove test bar from between centers by operating lever of footstock

(CAUTION: Do not move footstock because, if moved, the setup will need to be realigned.)

N. Twist sandpaper into a cone, and sand scale from center holes

O. Place work-driving dog on large diameter of workpiece near end

P. Put lubricant in center hole at each end of workpiece; place workpiece between centers

Q. Adjust footstock pressure

(CAUTION: Do not lock the spindle clamp of the footstock. The spindle has spring pressure to allow for expansion during grinding.)

R. Set work speed at 150 rpm

S. Set table feed at 25 ipm

T. Set wheel speed at about 5,600 sfpm

U. Dress wheel; clean table

V. Set table stops

W. Move wheel to workpiece and grind smooth

(NOTE: If taper is set correctly and workpiece machined properly, this procedure should require about 0.010 inch of feed.)

X. Move wheel back one revolution of cross-feed handwheel; remove workpiece

Y. Wipe workpiece with cloth, and apply a thin coat of Prussian blue about 3/8-inch wide along length of ground surface

Z. Slide workpiece into adapter or ring gauge, and rotate one revolution

JOB SHEET #5

AA. Remove taper gauge, and examine workpiece

(NOTE: The blue should have been smeared around the ground surface about 75 percent of its length; if not, the swivel table will need to be adjusted and the workpiece reground.)

BB. When taper is correct, continue to grind workpiece until small end measures 1.020 inches

CC. Stop coolant, workpiece, and table

DD. Allow wheel to run one minute to remove coolant; stop wheel

EE. Clean machine, and put away all tools

FF. Turn in workpiece to instructor for evaluation

CYLINDRICAL GRINDING
UNIT III

JOB SHEET #6 — GRIND AN INTERNAL SURFACE

I. Equipment and materials

A. Cylindrical grinder with coolant, four-jaw chuck, and internal grinding attachment

B. General-purpose internal grinding wheel, 1-inch diameter x 1/2-inch thick

C. Dial test indicator and holder

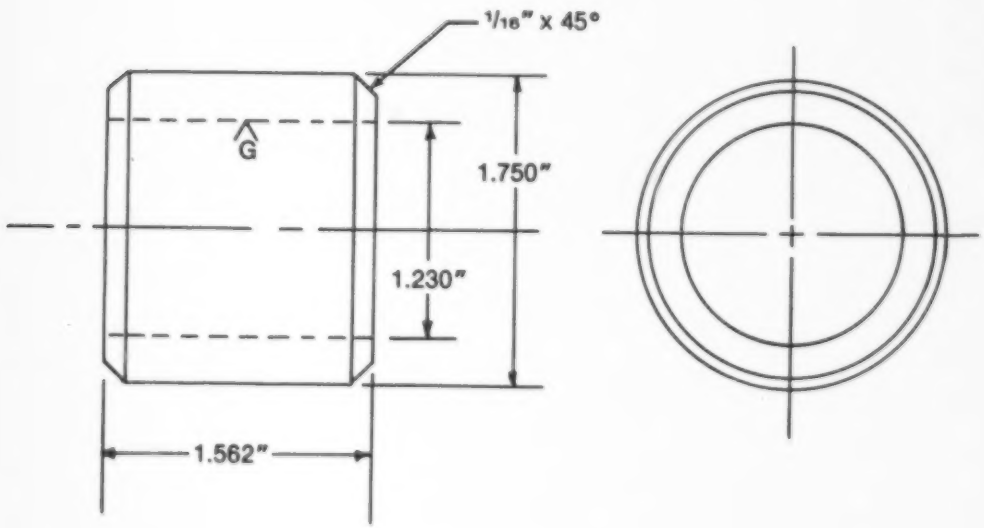
D. Micrometer, 1- to 2-inch

E. Telescoping gauge, 1- to 1 1/2-inch range

F. Clean shop towels

G. Steel pipe, premachined and heat-treated to 55 C ± 2 (Figure 29)

FIGURE 29



JOB SHEET #6

II. Procedure

A. Place workpiece in four-jaw chuck and align true to headstock

B. Set headstock to zero

C. Set headstock speed at 195 rpm

D. Unlock internal grinding spindle unit; secure in place

E. Check speed required for grinding wheel

F. Check speed of internal quill; change pulleys if necessary

(NOTE: Consult operator's manual for speed and pulley combinations.)

G. Set internal/external grinding switch knob for internal grinding

H. Set swivel table to zero

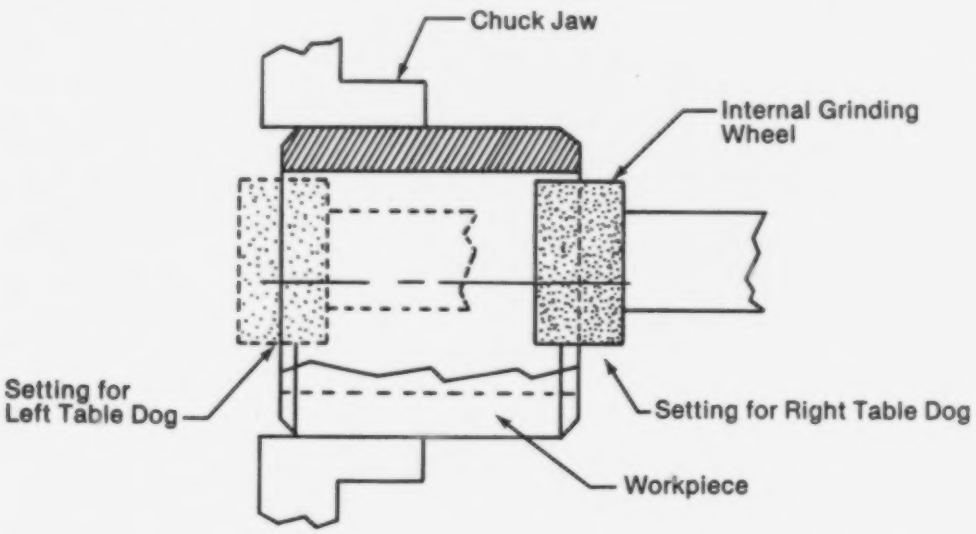
I. Mount internal wheel dresser, and dress wheel from back side; clean table

J. Set power table travel at a feed rate of 15 ipm, or one-quarter of wheel width per revolution of workpiece

K. Position internal wheel so that it will clear inside diameter of workpiece

L. Move table to position wheel center over left and right edges of bore; set table dogs (Figure 30)

FIGURE 30



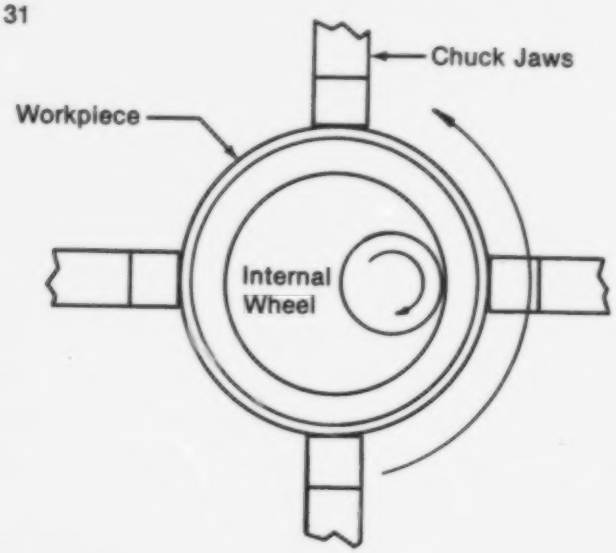
JOB SHEET #6

M. Set left and right table dwell for five seconds

N. Set cross feed for handwheel control

O. Start workpiece and internal spindle, and check for proper rotation (Figure 31)

FIGURE 31



P. Engage power for table travel

Q. Feed wheel to workpiece until it sparks

R. Feed wheel to workpiece at dwell right by manual feed at a rate of 0.0005 inch until bore surface has been ground

S. Note cross-feed setting, and move wheel away from workpiece

T. Stop table feed

U. Pull reversing lever back to move table left until wheel is about 2 inches from end of workpiece

(CAUTION: When moving the wheel away from the workpiece, make sure that you turn the cross feed so that the workhead will move toward you.)

V. Stop wheel

W. Use telescoping gauge to measure hole diameter

X. Subtract hole diameter reading from 1.251 inches to determine amount to be ground from workpiece

JOB SHEET #6

Y. Continue grinding until bore measures 1.251 inches

(NOTE: It may be necessary to dress wheel and use coolant to obtain proper finish.)

Z. Stop feed, and move wheel out of and away from workpiece

AA. Stop wheel and workpiece

BB. Remove workpiece from chuck

CC. Clean machine, and put away all tools

DD. Turn in workpiece to instructor for evaluation

CYLINDRICAL GRINDING
UNIT III

JOB SHEET #7 — GRIND AN ANGULAR SURFACE

I. Equipment and materials

A. Cylindrical grinder with coolant and four-jaw mounted chuck

B. General-purpose grinding wheel (mounted)

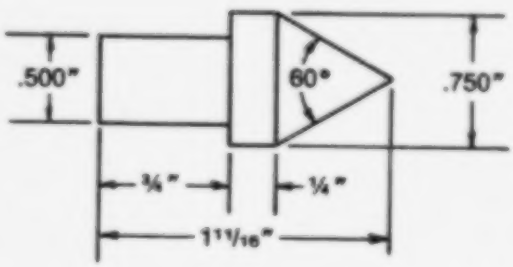
C. Table-mount wheel dresser with diamond

D. Dial test indicator with holder

E. Clean shop towel

F. SAE 4140 steel bar, 1¼-by-¾-inch, premachined and heat-treated to 58 C (Figure 32)

FIGURE 32



II. Procedure

A. Mount dresser and dress wheel

B. Align workpiece in chuck with pointed end extending from chuck

C. Set work speed at 250 rpm

D. Set table travel at 25 ipm, or set so that workpiece will travel about one-eighth the wheel width per revolution of workpiece

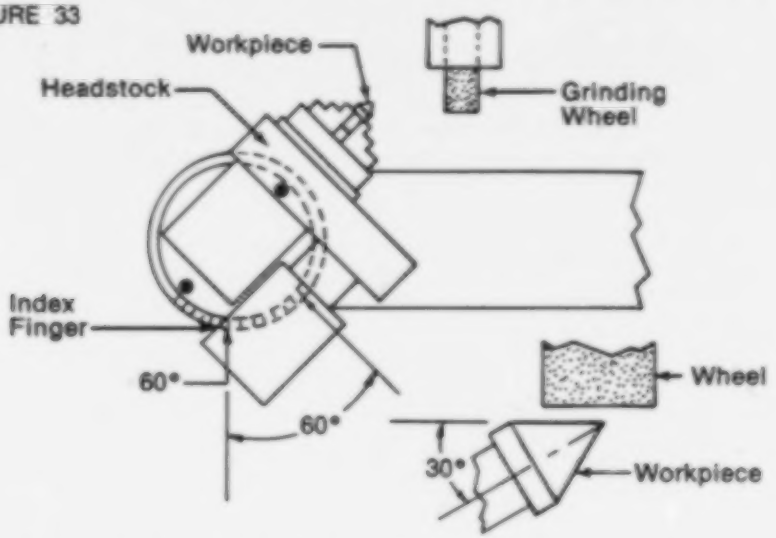
E. Set swivel table to zero

F. Loosen swivel clamp bolts on headstock

JOB SHEET #7

G. Turn headstock counterclockwise to a setting of 60 degrees (Figure 33)

FIGURE 33



H. Secure headstock swivel clamp bolts

I. Set right and left table dogs so that table reverses when workpiece is in contact with grinding wheel

J. Set right and left dwells for five seconds

K. Start wheel, coolant, and table

L. Move wheel to workpiece until it sparks

M. Set automatic feed at 0.0005 inch, and at feed right

N. Engage power feed, and allow wheel to grind workpiece until surface is round and end of workpiece comes to a point

O. Disengage power feed, and back wheel away from workpiece

P. Stop coolant, table travel, and wheel

Q. Remove workpiece from chuck

R. Clean machine, and put away all tools

S. Turn in workpiece to instructor for evaluation

CYLINDRICAL GRINDING
UNIT III

TEST

NAME _____ SCORE _____

1. Match terms associated with cylindrical grinding to their correct definitions. Write the correct numbers in the blanks.

_____a.	Number of revolutions per minute (rpm) that grinding wheel turns	1. ID (inside diameter) grinding
_____b.	Movement of table or workhead by hydraulic and/or mechanical feed	2. Feed index
_____c.	Grinding on outside circumference of a round workpiece	3. Work speed
_____d.	Cylindrical grinder with headstock and workhead that can be swiveled; used to perform OD, ID, and face grinding	4. Wheel speed (rpm)
_____e.	Rotation of workpiece at desired rate in opposite direction of grinding wheel	5. OD (outside diameter) grinding
_____f.	Center that does not revolve	6. Automatic feed
_____g.	Grinding on inside of workpiece to enlarge a bore or hole	7. Plain cylindrical grinder
_____h.	Rate at which wheel is fed into workpiece each time table reverses	8. Work feed
_____i.	Cylindrical grinder with headstock and workhead that are fixed; used to perform OD, straight, and taper grinding	9. Work rotation
_____j.	Number of revolutions per minute (rpm) that workpiece should turn to give correct surface speed and to obtain maximum wheel life, chip removal, and desired finish	10. Internal cylindrical grinder
_____k.	Mechanical feed device that allows for adjustment of feed depth	11. Live center
_____l.	Pause at one or both ends of table travel to permit grinding wheel to grind workpiece to size and to provide for completion of feed before table reverses direction	12. Dwell or tarry time
_____m.	Cylindrical grinder designed especially for ID grinding	13. Universal cylindrical grinder
_____n.	Center that revolves with workpiece	14. Dead center

TEST

2. Identify cylindrical grinding operations. Write the correct names in the blanks.

Taper grinding
Shoulder grinding
Internal grinding
Angular grinding
Plunge or infeed grinding
Contour (form) grinding
Straight grinding
Face grinding

_____a. Grinding end of workpiece by rotating surface to be ground at a 90-degree angle to grinding wheel

_____b. Grinding a conical surface that changes in diameter at a constant rate along its axis

_____c. Grinding a surface to a particular shape by means of a grinding wheel dressed to produce the desired shape

_____d. Grinding a cylindrical surface to an accurate size and finish, with sides parallel to center axis throughout its length

_____e. Grinding a surface 90 degrees to axis of workpiece

_____f. Grinding a surface or shape by feeding wheel into workpiece with cross feed; can be performed on external or internal surfaces

_____g. Grinding an angle by rotating workhead at desired angle to grinding wheel

_____h. Grinding a hole or bore to an accurate size, taper, or finish

3. Arrange in order procedures for removing and replacing a grinding wheel. Write a "1" before the first step, a "2" before the second step, and so on.

Removing wheel

_____a. Use wheel-sleeve puller to loosen sleeve

_____b. Store wheel if it is not damaged; otherwise, discard

_____c. Remove outer portion of wheel guard

_____d. Remove puller, and slide sleeve from tapered spindle

_____e. Take off spindle nut

_____f. Use wrench to remove sleeve from wheel

TEST

Mounting wheel

_____a. Check wheel balance; balance if necessary

_____b. Stand to one side, jog start grinder, and allow wheel to reach operating speed and run for one minute

_____c. Use wrench provided by manufacturer, or torque wrench, to tighten all screws snugly in an alternating sequence

_____d. Place sleeve on spindle, and secure spindle nut

_____e. Clean spindle and surface of fixed flange and/or wheel sleeve

_____f. Place outer flange on sleeve, place screws in holes of outer flange, and finger-tighten all screws

_____g. Ring test the grinding wheel

_____h. Replace wheel guard

_____i. Clean machine, and put away tools

_____j. Slide wheel and blotters onto wheel sleeve

4. Arrange in order steps for dressing wheel for cylindrical grinding. Write a "1" before the first step, a "2" before the second step, and so on.

_____a. Advance wheel 0.0005 inch for each pass across wheel, until face of wheel is completely dressed

_____b. Position dresser so that it is clear of wheel

_____c. Clamp diamond in holder

_____d. Start grinder, and allow spindle bearings to warm up

_____e. Stop wheel

_____f. Set table travel at 5 to 10 inches per minute (ipm), or set in truing position indicated by manufacturer

_____g. Clean dust from tools and equipment

_____h. Feed wheel so that diamond contacts point at largest diameter on grinding-wheel surface

_____i. Turn on coolant if necessary

_____j. Remove diamond and holder if required

_____k. Position diamond if holder is adjustable

TEST

5. Name five types of wheel dressers.

   a. _____

   b. _____

   c. _____

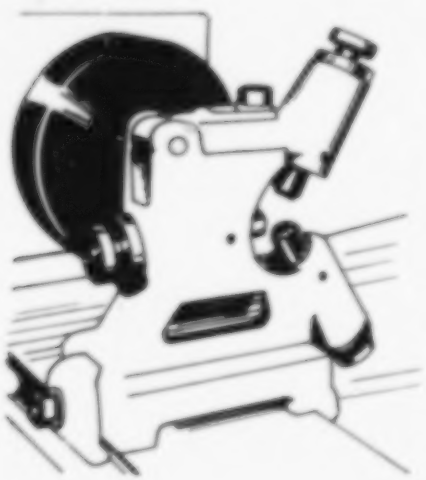
   d. _____

   e. _____

6. Identify accessories used with cylindrical grinders. Write the correct names in the blanks.

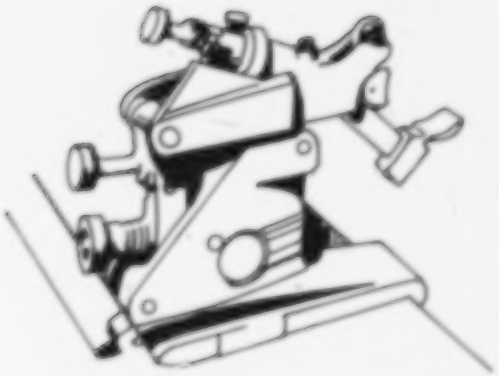
Driving dogs
Three-jaw chuck
Universal backrest with adjustable shoe
Four-jaw chuck
Collet chuck
Center rest
Magnetic chuck
Headstock and footstock centers
Faceplate

a.

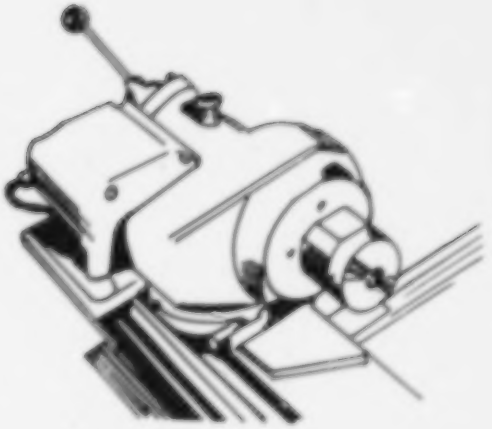


a. _____ b. _____

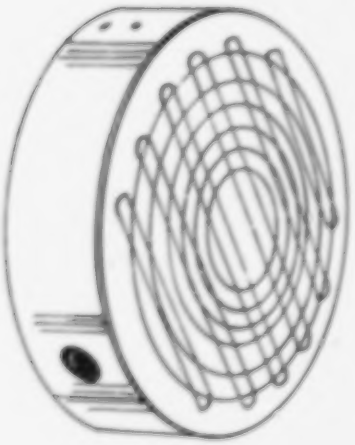
TEST



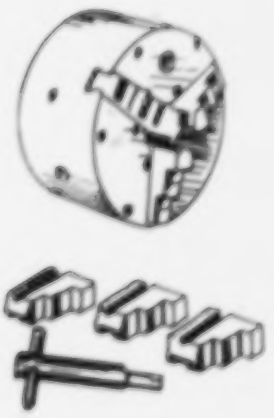
c. _____



d. _____

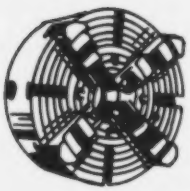


e. _____

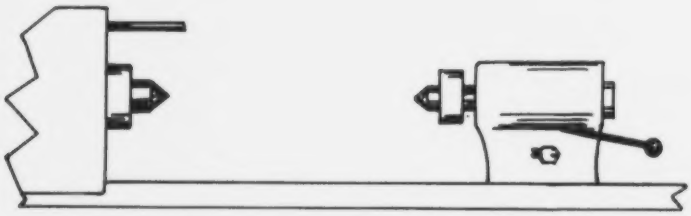


f. _____

TEST



g. _____ h. _____



i. _____

7. Match accessories used with cylindrical grinders to their correct functions. Write the correct numbers in the blanks.

_____a.	Holding and driving workpieces for external grinding operations of small workpieces that do not vary in size; allows quick clamping	1. Faceplate
_____b.	Supporting long workpieces so that accuracy can be maintained and chatter can be eliminated during grinding operation	2. Driving dogs
_____c.	Holding and driving workpieces for external or internal grinding operations	3. Chucks
_____d.	Supporting workpiece at each end for external grinding operations	4. Collet chuck
_____e.	Driving workpiece held between centers	5. Center rest
_____f.	Supporting long workpieces for external or internal grinding operations	6. Universal backrest with adjustable shoe
_____g.	Holding and driving workpieces for external or internal grinding operations that cannot be chucked; allows mounting of fixtures	7. Headstock and footstock centers
_____h.	Holding and driving thin workpieces that cannot be chucked in a conventional chuck for face grinding	8. Magnetic chuck

TEST

8. Select from the following lists probable causes of grinding problems. Write an "X" in the blank before each correct answer.

Chatter

_____a. Table travel too slow

_____b. Wheel too hard

_____c. Machine vibrating internally

_____d. Machine improperly mounted or located

_____e. Workpiece not supported properly

_____f. Wheel out of round

_____g. Work speed too low

_____h. Centers worn or out of alignment

_____i. Grinding wheel loose on sleeve

_____j. Feed excessive

Scratches on finish

_____a. Wheel too soft

_____b. Wheel edge ragged

_____c. Coolant dirty

_____d. Wheel out of balance

_____e. Table travel too fast

_____f. Wheel too coarse

Spirals on finish

_____a. Workpiece center holes not true or clean

_____b. Workpiece loose on centers

_____c. Centers fitted poorly in spindles

_____d. Table travel too slow

_____e. Loose grain particles on wheel

_____f. Wheel edge ragged

_____g. Coolant inadequate

TEST

Wavy lines on finish

_____a. Wheel out of round

_____b. Machine vibrating externally

_____c. Machine improperly mounted or located

_____d. Gear action faulty

_____e. Wheel out of balance

_____f. Centers worn or out of alignment

_____g. Workpiece too tight on centers

_____h. Wheel edge ragged

Burnt or discolored finish

_____a. Wheel speed too low

_____b. Wheel too soft

_____c. Coolant inadequate

_____d. Workpiece speed too low

_____e. Wheel loaded or glazed

_____f. Coolant not properly directed

_____g. Feed excessive

_____h. Grinding wheel material wrong

_____i. Table travel too fast

_____j. Wheel too coarse

Feed line on finish

_____a. Coolant not properly directed

_____b. Table travel incorrect

_____c. Grinding wheel material wrong

_____d. Wheel loaded or glazed

TEST

_____e. Workpiece not supported properly

_____f. Wheel edge ragged

_____g. Centers worn or out of alignment

Inaccuracies in workpiece

_____a. Workpiece too cold

_____b. Workpiece loose on centers

_____c. Centers worn or out of alignment

_____d. Gibs loose or table ways worn

_____e. Workpiece center holes not true or clean

_____f. Wheel out of round

_____g. Centers fitted poorly in spindle

_____h. Headstock or swivel table not properly aligned

_____i. Wheel loaded or glazed

Intermittent cutting action

_____a. Wheel out of balance

_____b. Table travel incorrect

_____c. Workpiece too tight on centers

_____d. Coolant not properly applied

_____e. Workpiece out of balance

_____f. Workpiece too hot

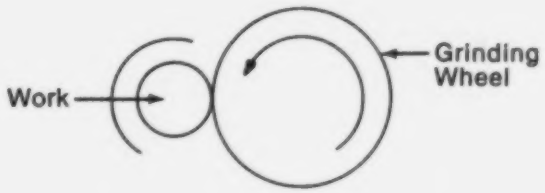
_____g. Wheel out of round

_____h. Wheel loaded or glazed

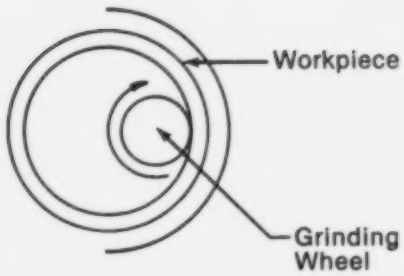
TEST

9. Determine work rotation with respect to wheel rotation by adding arrowheads to the arcs for the workpieces shown below.

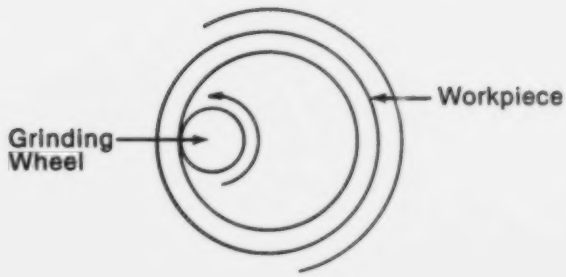
a.



b.



c.



TEST

10. Calculate wheel speed (rpm), work speed, and rate of table travel (ipm). A 3-inch hardened steel shaft must be ground using a 2-inch wide, 12-inch diameter wheel and a surface speed of 6,000 sfpm.

(NOTE: For this test item, use 2/3 or 0.67 wheel width in calculating rate of table travel for rough grinding.)

a. What is the wheel speed? _____ rpm

b. What is the work speed? _____ rpm

c. What is the rate of table travel for rough grinding? _____ ipm

(NOTE: Test question 11 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

11. Demonstrate the ability to

a. Remove and replace a grinding wheel.

b. Use table-mounted holder to dress a grinding wheel.

c. Grind a workpiece straight and to size.

d. Grind a workpiece to dimension.

e. Grind a #4 Morse taper.

f. Grind an internal surface.

g. Grind an angular surface.

CYLINDRICAL GRINDING
UNIT III

ANSWERS TO TEST

1.

a.	4	h.	8
b.	6	i.	7
c.	5	j.	3
d.	13	k.	2
e.	9	l.	12
f.	14	m.	10
g.	1	n.	11

2.

a.	Face grinding	e.	Shoulder grinding
b.	Taper grinding	f.	Plunge or infeed grinding
c.	Contour (form) grinding	g.	Angular grinding
d.	Straight grinding	h.	Internal grinding

3.

Removing wheel		**Mounting wheel**	
a.	3	a.	6
b.	6	b.	9
c.	1	c.	5
d.	4	d.	7
e.	2	e.	1
f.	5	f.	4
		g.	2
		h.	8
		i.	10
		j.	3

ANSWERS TO TEST

4.

a.	7	g.	11
b.	8	h.	4
c.	1	i.	6
d.	3	j.	10
e.	9	k.	2
f.	5		

5. Answer should include any five of the following

   a. Footstock-mounted dresser

   b. Table-mounted dresser

   c. Radius dresser

   d. Angle dresser

   e. Radius and tangent dresser

   f. Crush roll dresser

   g. Built-in dresser

6. a. Center rest

   b. Faceplate

   c. Universal backrest with adjustable shoe

   d. Collet chuck

   e. Magnetic chuck

   f. Three-jaw chuck

   g. Four-jaw chuck

   h. Driving dogs

   i. Headstock and footstock centers

ANSWERS TO TEST

7.	a.	4	e.	2
	b.	6	f.	5
	c.	3	g.	1
	d.	7	h.	8

8. **Chatter**

b, c, d, e, f, h, i, j

Scratches on finish

a, b, c, e, f

Spirals on finish

a, b, c, e, f

Wavy lines on finish

a, c, d, e, g, h

Burnt or discolored finish

c, d, e, f, g, h, i

Feed line on finish

a, b, c, e, f, g

Inaccuracies in workpiece

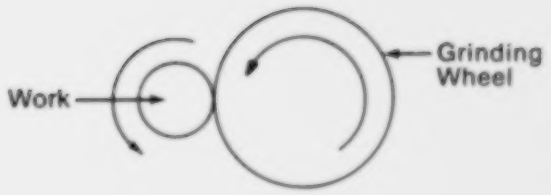
b, c, d, e, g, h, i

Intermittent cutting action

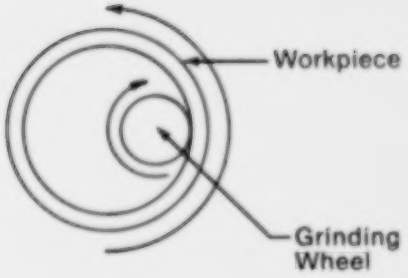
a, c, d, e, f, g

ANSWERS TO TEST

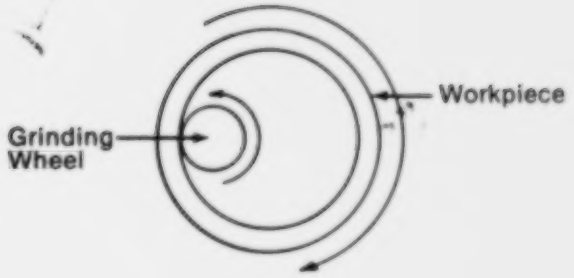
9. a.



b.



c.



10. a. 1,900 rpm

b. 66.6 rpm

c. 44.6 ipm

11. Performance skills evaluated to the satisfaction of the instructor